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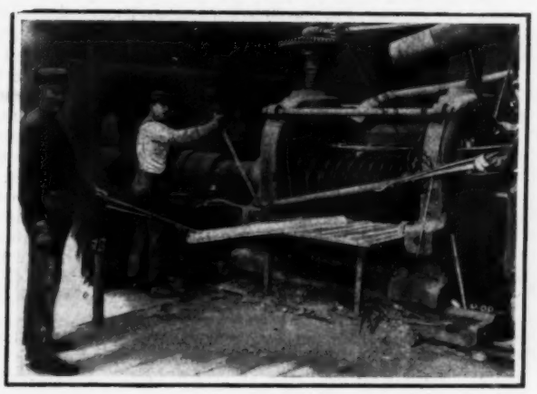
RETORTS FILLED WITH TUBES TO BE ANNEALED VERY SOFT.

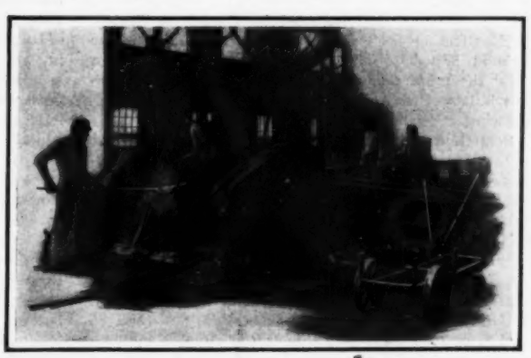
GROUP OF FINISHED SEAMLESS STEEL CARBONIC-ACID GAS CYLINDERS.

SAWING PIERCED BILLETS.

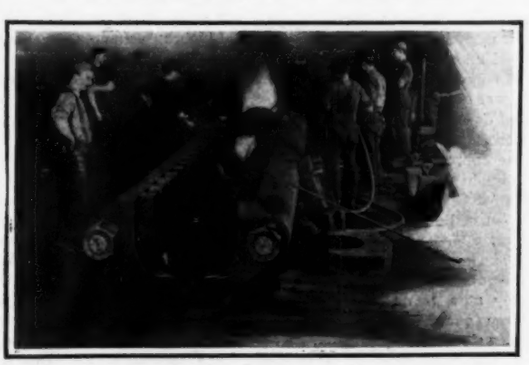
GROUP OF CUPS. FIRST PROCESS IN MAKING SEAMLESS TUBES OF LARGE DIMENSIONS.



ROLLING TUBES, HOT, AFTER PIERCING OPERATION.



HEATED BILLET ENTERING PIERCING MILL.



HOT-DRAWING BENCH WITH TUBE IN PROCESS.

THE MAKING OF A COLD-DRAWN STEEL TUBE.

THE MAKING OF A COLD-DRAWN STEEL TUBE.

A DESCRIPTION OF THE SHELBY PROCESS.

THAT brass and copper can be readily drawn into tubular shape while cold seems to be a fact quite easily accepted by minds not trained in the possibilities of engineering; but that steel can with almost equal facility be drawn to any size or thickness without being heated, at least to redness, is a fact not so universally admitted. There is a lurking belief that the word "cold" is merely relative, and that it does not mean atmospheric temperature. It is hard for those who are not either engineers or makers of cold-drawn steel tubing to believe that a tube can be picked up cold from the floor and passed in a minute's time through the dies of the draw-bench, and be reduced perceptibly in both diameter and thickness by that operation.

That tubes are really thus made is exemplified daily in the works of the National Tube Company. By courtesy of that company we will give here a detailed explanation of the processes followed in the manufacture of Shelby seamless steel tubing.

SEAMLESS PROCESSES.

The possibility of producing a homogeneous and ductile steel in large quantities is a comparatively recent achievement, and to it entirely we owe the remarkable development and success of the seamless steel tube industry in this country and abroad." The early efforts of experimenters who aimed at seamless tubes in steel show the influences of the old methods followed for the ductile metals, brass and copper. This analogy is inevitable. The first railway passenger cars were patterned after the carriages then in use, but they have gradually taken the form best suited to their functions and scope. The early steamboats were made as nearly as possible like sailing vessels, but now we have modified even the hull, so that almost the only analogy which remains is that both float.

So, in breaking away from the old methods of making brass and copper tubes, we find the expected steps of departure. What seems to be the first attempt to make seamless tubes appears in 1837, under the English patent of Hanson. This provides a thick, short cylinder of cast-steel, which is raised to a very high temperature and placed in a matrix, and then by means of a hydraulic ram the metal is squeezed through a small orifice around a punch, a seamless tube being the result. This method, with a few modifications, was again patented in England in 1867. A similar process was patented by Elliot in 1882. Under this specification plastic or molten steel was to be forced hydraulically through a suitable orifice so that a tube with the fibers arranged helically would be produced.

The swedging mill patented by Church & Harlow in England in 1841, and subsequently modified under patents issued to Mannesmann and Stiefel, had in view the more economical means of lengthening hollow billets of cast or drilled steel, preparatory to cold-drawing.

Sometimes solid bars of steel were drilled from end to end to make a tube-shape suitable for the cold-drawing operation, but this process was slow and expensive. There was a time, however, when bicycle tubing commanded in this country a price as high as $2 a pound, and it was only on the strength of such a market that the early methods of production were practicable. One of the first attempted processes, while not successful for small tubes, has since been satisfactorily developed for tubes larger than 5 inches outside diameter; this is the cupping method, which consists in pressing a cup or cap from a flat plate and progressively elongating it into a tube by decreasing the diameter while it passes through a series of reducing dies. This method is practised in the manufacture of tubes from 5 to 30 inches in diameter, and will be referred to again.

In making seamless tubes from cast-steel cylinders, it was found that the material was not homogeneous and developed blow-holes while being drawn. Furthermore, it was not uniform in hardness and texture. The cupped plates did not permit the manufacture of tubes in all commercial lengths or thickness, and the drilled bars yielded costs which were prohibitive even when selling prices were much higher than they are now.

The sudden and remarkable growth of the bicycle several years ago made seamless tubes necessary not only at a comparatively low price, but primarily in large quantities; the early modes of manufacture were slow and tedious, and orders aggregating millions of feet were waiting to be filled. The outlook was bright, even if limited entirely to the field of the bicycle, and plans for seamless-tube mills were prepared at many points, chiefly in the regions where bicycles were being made. All these plans, nevertheless, failed to show a simpler, quicker, and more economical means of securing what is now called the pierced billet, or the steel in suitable condition for passing to the draw-benches. Tubes had to be obtained, however, and plans were carried forward, with the piercing proposition left to care for itself, at least until the pressing demand could be partly satisfied, and experience gained by the way. Pierced billets were imported from Europe to be drawn down to the sizes required in this country for bicycles. As long as the piercing operation was left aside, it was a simple and relatively inexpensive matter to start a seamless-tube plant, and the natural result was a draw-bench or two here and there all over the manufacturing section, where tubes were made to meet the steadily increasing demand.

It was well known that greater production and lower costs would result from an improvement of the piercing devices then in use, and the much-sought object was finally developed by Mr. R. C. Stiefel and put into service as the Stiefel piercing machine. While the piercing process was being perfected, steel-makers were engaged in producing a uniform quality of mild steel which would permit satisfactory piercing and cold-drawing and yield also a finished tube with all the required physical attributes. Both quests —for a machine to work and a steel to be worked— were practically satisfied at the same time, and seamless steel tubes then began to count as a respectable branch of the great steel industry in America.

THE MANUFACTURE OF SHELBY SEAMLESS STEEL TUBING FROM BILLETS.

Much of the success of Shelby seamless tubing is due to the excellent qualities of the steel used. This steel is shipped to the rolling mills in blooms 7 inches square in section, and about 6 feet long, weighing approximately 750 pounds each. Before being rolled each bloom is carefully inspected for surface defects, and all irregularities are chipped off with pneumatic hammers. The blooms are then sent to the heating furnace, and after acquiring a suitable temperature are rolled from their square section to round bars, which vary in diameter according to the size of tubes required to be made from them. Some of the bars are 6 inches in diameter when finished; others are as small at 2½ inches. For convenience in shipping, they are cut to lengths of about 10 feet, and sent to the various tube mills on factory requisitions.

The piercing machines at each mill have different capacities, in sizes and quantities; the "rounds" must therefore be cut again into pieces which will furnish with the least waste the size, length, and thickness of tube required by the factory's orders. After being cut to the working length, the steel is known as a billet. It may be from 1 to 5 feet long; but it must contain as many cubic inches of steel as the finished tube, plus enough to cover the losses incidental to manufacture.

It is important that the piercing point should strike the very center of the solid billet as it advances, for if it does not the steel will be thicker on one side of the finished tube than on the other, and no amount of careful cold-drawing can correct the eccentricity. To insure the passage of the point through the center of the billet, each one is drilled suitably before it passes to the heating furnace. The bottom of the furnace is inclined, and the centered billets of the proper length are fed into the upper and cooler end, from which they roll by gravity to the lower end, where the temperature is high enough to render the steel soft and semi-plastic. Close to the discharging end of the furnace the piercing mill is located, and the billets are fed into it, centered end foremost, either automatically or, in the smaller mills, by hand.

The solid billet, almost white hot, is pushed forward until it is caught by the revolving piercing disks, and from that point onward the machine completes the operation without the touch of a human finger. When the billet reaches the stationary piercing point of malleable iron, and starts to pass over it, forced by the forwarding and revolving action of the heavy rotating disks, only a slight, dull, grinding sound is audible; there is nothing spectacular about the operation, nor much suggestion of the enormous power required to displace the metal from the center of the hot billet toward the outside. So powerful are the piercing disks and so carefully planned is each part of the massive machinery that the billet is apparently molded into a tube with the same freedom as a lump of dough is manipulated by a pastry cook. When the tube emerges from the machine, hot gases burn lividly from its ends; the inspectors look over it carefully for possible defects, and if it is perfect it is rolled at once to the saw, which cuts it in two pieces almost instantly; a shower of sparks and a ringing noise accompany the operation.

The newly-pierced billet is simply a rather rough, thick-walled, scaly, seamless tube. It is raw in appearance and not particularly true to size, and it retains the corrugations of the piercing disks on its scarred surface. But it is positively without a seam or weld, the round bar of steel having been pierced quite through its length, as a potter would force a pointed rod through a cylinder of moist clay. It is short, because most of its substance is yet in its walls, and to change thickness into length is the next requirement. Accordingly the tube is passed once more to a heating furnace, and at the proper temperature it is rolled over long round bars of tool steel, through grooves successively smaller, and in this manner converted into a long, thin-walled tube with a fairly smooth surface finish.

Even now it is only a hot-rolled tube, and lacks accuracy in diameter, gage, and rotundity. One more operation known as "pointing" is needed to make it ready for the bench-room, where it will earn by slow, careful, and exact manipulation the distinguishing qualities that result from being cold-drawn. "Pointing" consists in hammering the heated end of each tube into a solid point, which can be caught by the heavy tongs of the drawbench in which the tube is to be cold-drawn.

Before tubes can be cold-drawn they must be clean and free from scale. They are therefore pickled in acid bath which is heated and kept in constant agitation by jets of steam.

The operation of cold-drawing is extremely simple in principle, and not in any manner new. It is practically the same for steel tubes as it is for brass and copper. All that is necessary is strong machinery and enough power to move it. The benches are substantially built of steel, and each is furnished with a heavy, square-linked chain, which runs over a wheel placed just underneath the die. This chain extends along the bed of the bench, for from 15 to 40 feet, to a sprocket which is geared to the main shaft from the engine, and it returns underneath the draw-bench. Dies are made from the very best grade of crucible steel, and are machined to the thousandth of an inch, to govern the outside diameter of the tube which is to be drawn. All tubes except those smaller than ½ inch inside are drawn over a mandrel. This mandrel is kept in position by a long bar which goes inside of the tube and holds the mandrel just even with the die while the tube is being pulled.

The drawing operation hardens the metal and makes it necessary to anneal every tube before it can be drawn again. It must be remembered that it may require from two to twenty passes through dies of varying diameter to produce a tube with the required dimensions. Such a tube must be annealed after each pass to eliminate all the brittleness of the steel which resulted from previous cold-draw passes and to permit further drawing.

The process of annealing is attended with the formation of scale; and, from the remark made in a previous paragraph, this necessitates a return of each tube to the pickle bath each time it is annealed. The intermediate anneals, or anneals between bench-passes, are made in open furnaces; but for the consumer tubes are annealed to the buyer's specifications.

The "points" of the tubes remain until after the last pass through the dies, which brings the tube to the desired outside diameter and thickness; then, after the requisite anneal has been given, the tube passes to the cutting-off machines, where it is either cut to specified lengths or multiples, or cut to the best advantage in random lengths. Boiler tubes are tested by hydrostatic pressure, but mechanical tubes are not so treated.

From the cutting department, the last step in the process is to the shipping room or to the stock racks, of which partial views are shown in this article.

SEAMLESS TUBES MADE FROM PLATES.

The processes described and illustrated in the foregoing are those followed in the manufacture of seamless tubes and tubing from solid steel billets. These processes are employed for all sizes up to and including tubes 5½ inches outside diameter; but for tubes larger than this the methods are different. It will be readily comprehended that to obtain a seamless tube, say 20 inches in diameter, from a solid cylinder of steel would necessitate piercing machinery of most gigantic and unwieldy proportions, and to

drive such machinery would require great power.

Now, in small tubes the ratio of length to diameter is large. Taking a tube measuring ½ inch outside, it is possible to produce it in lengths as great as 40 feet, and the ratio of length to diameter in this case is 960. There are many uses for tubes of this size and length. But a tube 20 inches in diameter is rarely called for in lengths greater than from 6 to 10 feet, and in this case the ratio of length to diameter is not more than 6. Therefore very large, heavy-walled tubes are made from plates of steel, rolled in squares.

The first "cupping" process seems to have been patented in England by Remond in 1851, and was intended for small tubes as well as those of considerable size, but at the present time only the large tubes are made from plates. The amount of waste being known or approximated, and the volume of metal in the finished tube being calculated, we have two amounts, which, added together, indicate the approximate size of steel plate required for a given specification. Plates are made from the same grade of steel as are billets for the smaller sizes, and are shipped to the mills in squares varying in thickness from ⅜ inch to 3 inches, and in size from 2 to 6 feet across.

The corners are first sheared off to produce a circular disk, which is heated to redness, withdrawn and placed on the anvil of an immense hydraulic press, by which the plate is punched into a rough, shallow cup. The cup is again heated and punched through a smaller die to elongate or deepen it, and at the same time to reduce its diameter. Perhaps it goes a third or fourth time through a similar operation before it is ready for the finishing passes on the hot-draw bench. This apparatus, as shown by the engraving, consists of a heavy cast-steel frame or body, provided with a powerful hydraulic cylinder and a plunger which operates through the full length of the bench. Plungers of various sizes are used according to the size required in the finished tube, and dies of successively decreasing diameter are dropped in recesses in the bench-frame in positions so that the heated elongated steel cup may be forced through them one after another, the final and smallest one pressing the steel down tight toward the plunger for the full length of the tube. The plate has now passed almost completely into tubular form, and the original head, or the bottom of the "cup," forms but a small proportion of it. Subsequent hot-drawing operations may be necessary to produce a tube with a smaller diameter, a thinner wall, or a greater length. Finally the head, or closed end of the tube, which remains until the last operation is completed, is cut off, and the process is finished.

Hot-drawn tubes are not as smooth as those which have been cold-drawn. The latter are listed up to and including 5½ inches outside diameter, but occasionally it is necessary to produce tubes larger than this with walls as smooth as possible; in such cases, if the tube is not too heavy, and not over 8 inches in diameter, hot-drawn material can be passed from one to three times through finishing dies, cold.

SPECIAL OPERATIONS

For use as bushings, hose mandrels, roller bearings, lathe spindles, etc., the only preparation that is necessary on a seamless tube is to cut it to the proper length. But the uttermost boundaries of the possible uses of Shelby seamless tubing have not been found. A dozen years ago it had one destination only—the bicycle; now it has thousands of uses. Many of its applications are simple and direct, but in countless other instances it is merely the basis of more complex structures. To meet the demand for special forming operations mills have been fully equipped for carrying out the heaviest and most difficult kinds of special work on tubing of all sizes and thicknesses. Machinery is designed for flanging and bending tubes for automobile axles, upsetting drill-rods, swedging, expanding, cupping and tapering tubes, and other varied manipulations of a kindred nature.

WIRELESS TELEGRAPHY IN NAVIGATION.

THE PRINCIPLES OF THE LAIR PROCESS.

NAVIGATION in foggy weather near coasts is fraught with danger. When the navigator cannot see land by day or lights at night, or even the sun or stars, no means of determining the position is left, and in the statistics of shipwreck fog is recorded as the commonest cause. At certain points, for example, near the harbor of Brest, useful indications can be obtained by sounding, but at best this is an inexact method. Some lighthouses possess sirens which warn ships of the proximity of land, but the range of these signals is diminished by thick fog, and consequently at the very time when they are most necessary. Finally, certain particularly dangerous spots have been equipped with submarine bells, the sounds of which are easily detected by special receivers on vessels at a distance of five nautical miles. This class of signals appears for the moment to be the most effective, although its range is not very great and it gives only a vague indication of danger without giving information of its exact direction or distance.

It has been proposed to make use of wireless telegraphy. If, for example, we imagine a powerful station on the coast, emitting at regular intervals trains of waves of uniform length, all ships within several hundred miles, that are provided with receivers, would detect and recognize these oscillations and would thus be informed of their entrance into the zone of influence of the station.

This would also be only a vague indication. Various methods of giving more precise information have been attempted. It has been proposed to use polarized waves, that is to say, waves having a maximum effect in a given direction; but the axis of polarization could not be determined within 20 deg.; and in order to locate it, it would be necessary for the vessel to depart from its course and travel a considerable distance. The polarization of the receiving antenna would be preferable, but it is impracticable on board ship, and it could not be effected with sufficient precision. The combination of wireless signals with sound signals, either aerial or submarine, emitted simultaneously, the difference between the times of reception of the two signals allowing the distance to be calculated from the known velocity of sound, gives good results only for a short distance; and even these results are affected by the difficulty of noting the time exactly. It seems possible that a new process recently invented by Lieut. Lair of the French navy is capable of giving more accurate results.

The principle of the process is the following: The distance of the emitting station is determined by the quantity of energy received at the receiving station. The emitted waves being rigorously uniform, the quantity of energy received is inversely proportional to the square of the distance. With sufficiently sensitive measuring apparatus it is possible to locate the ship in a few minutes on a circle of definite radius drawn around the emitting station. If immediately afterward it is possible to receive waves emitted by a second station at a sufficient distance from the first and producing waves of different intervals and duration, the ship would be located on a second circle, and the intersections of these circles on the chart would give the vessel's exact position. If the waves from one post only are received the position of the vessel could, nevertheless, be traced by two successive operations. Having traced the circle corresponding to the first measurement, the course is pursued for 15 minutes or half an hour and a second observation is made, which gives a second circle concentric with the first. The speed of the vessel being approximately known, as well as the distance that has been traversed in the interval, it is possible by a simple geometrical construction to find the two points of these circles which are separated by the distance traversed. This method appears to be susceptible of practical employment. The first experiments appear conclusive, but before deciding definitely it is proper to await the results of more elaborate tests which will shortly be made with a special wireless station, erected probably at Ouessant.

The emitting station should be provided with an alternator which can be regulated perfectly in speed and in the amount of energy developed. The acquirement of such perfection will probably be found to be the greatest difficulty. The antenna should be made so as to radiate with equal intensity in all directions in which its radiations are required. An automatic commutator driven by a small motor should control the wireless signals, which, like the lights, should be operated according to a pre-arranged scheme. The receiving station comprises an antenna fixed with respect to the hull and rigging of the vessel and tuned to exact harmony with the emitting antenna. The auxiliary apparatus aboard ship includes:

1. A wattmeter for approximate measurements, composed of telephones intercalated in a secondary circuit, of which the primary is a coil connected with the antenna.

2. An index of emitting stations, consisting of a relay operating a chronograph, which measures the length of the wave trains and their intermissions.

3. The integrating wattmeter, which is simply a bolometer of the laboratory model, provided with a rheostat and with a galvanometer, which may, if preferred, be graduated to indicate the distance directly.

Before this or some similar system can become commonly employed, it is probable that wireless telegraphy will render some slight service to navigators in the following manner: At the suggestion of M. Bouquet de la Grye experiments are being made on the possible organization of hour signals to be emitted from the Eiffel Tower, by means of which navigators will be able to determine their longitudes and regulate their chronometers with accuracy and certainty.—Revue des Sciences.

CENSUS STATISTICS OF THE STREET RAILWAY INDUSTRY.

THE electric railway industry is developing so rapidly that the Census Bureau did well to make quinquennial collection of the statistics, instead of waiting until ten years following the last report, or until 1912. The census, for which the preliminary figures are available this week, is for the year ended December 31st, 1907, and it is interesting to notice that they correspond closely to the unofficial figures published last August by this paper. The census figures for 1902 are also included in the table published this week. The most striking feature of the record is the large increase during the past five years in mileage, cars, and earnings from operation. The latter, indeed, have grown 68.9 per cent in the five years, or practically 14 per cent per year, and during the year ended December 31st, 1907, reached the enormous total of $418,187,858. This amount, however, includes the earnings from lighting and power service of those electric railway companies which are also engaged in the commercial lighting and po ver business, but is exclusive of income from securities owned, returns from investment in real estate not used for operation purposes, etc. The receipts from lighting and power in the 1902 report were something over $7,000,000, and could probably be conservatively estimated during 1907 at about $20,000,000. Deducting this amount from the earnings from operation quoted above, the earnings from purely railway operation would be slightly less than $400,000,000. This is approximately one-fifth of the gross earnings from operation of the steam railroads of the country reporting to the Interstate Commerce Commission for the year ended June 30th, 1906, and is equal approximately to four-fifths of the passenger revenue of these steam railroads.

It is interesting to note that during the past five years the operating expenses of the electric railway companies have increased practically 8 per cent more than the earnings from operation, or 76.6 per cent, instead of 68.9 per cent, and that taxes and fixed charges increased practically 10 per cent more than earnings from operation, so that the net income of the electric railway companies shows an increase of only 31.8 per cent, or less than half that of the gross, as compared with five years ago.

The capital stock outstanding has increased 59.5 per cent and the bonds outstanding 72.9 per cent during the five-year period, making the total outstanding capital liabilities $3,774,772,096. This represents an increase of 59.5 per cent in capital stock and of 68.9 per cent in outstanding bonds, or the ratio of net income to capital stock outstanding during 1907 was practically only 2 per cent and the ratio of the increased net income to increased capital stock since 1902 was only 1.2 per cent. The table of averages gives some interesting figures in this connection, as it shows increases in salaries and wages paid of 73.5 per cent and 71 per cent, respectively. The wage earners, however, have gained per individual by this change more than the salaried employees, as their wages have increased 8.2 per cent, while the remuneration of the average salaried employee has advanced only 5.6 per cent.

Turning now to the statistics on physical equipment, the combined effect of consolidations and the development of long-distance power transmission engineering is clearly indicated in the small increase, only 2.7 per cent, in the number of power stations, while the development of high-powered station apparatus is clearly shown in an increase of only 8.5 per cent in the number of steam and gas engines, but an increase of 92.2 per cent in their kilowatt capacity and 110.4 per cent in the kilowatt-hour output. The table also testifies in a striking way to the development in the direction of longer cars by the disproportionately low increase in the number of cars and car-miles compared with that of passengers carried, and to the rapid extension of the use of transfers since 1902 in the ratio between increase of fare passengers and of transfer passengers.—Electric Railway Journal.

UNIVERSAL CAMERA BRACKET.

HOW TO PHOTOGRAPH OBJECTS LAID ON A FLOOR.

BY ETHAN VIALL.

THE writer has devised a simple camera holder to be used when photographing tools or other objects laid on the floor. The camera bracket combines the features of being universal, rigid, and cheap. It is far superior to the ordinary ball and socket joint universal camera holder, where the camera is liable to fall over in any direction when the thumb nut is loosened.

The accompanying illustration, Fig. 1, shows very plainly the general construction of the bracket, and the illustrations, Figs. 2, 3, and 4, show the camera in different positions, mounted on the tripod. The detail dimensions given below are for brackets used with a 5 by 7-inch camera. The top and bottom boards, which are each made of three layers of wood glued together, are 5¼ inches wide, 7½ inches long, and ⅜ inch thick. The top of the tripod, on which the bracket is mounted, is 5 inches in diameter, and the boards were made 5¼ inches wide, in order to make the side clamping pieces clear the top of the tripod. The two boards were made by a trunk maker for 35 cents. The two hinges are common 1¼-inch brass hinges which will cost 5 cents. The two thumb nuts and the thumb screw required may be bought for another nickel. The adjusting slides are cut and filed out of 1/16-inch spring brass, the slot in them being 2¾ inches long, and just wide enough to admit a 3/16-inch bolt. This bolt is made like an ordinary stud bolt, except that it is provided with wood-screw threads on one end. The end provided with standard threads has a screw-driver slot cut into it. A brass nut is set into the lower board, 2½ inches from the edge on which the hinges are fastened. The regular tripod thumb screw is screwed into this nut. The thumb screw which fastens down the camera is set into the upper board 3½ inches back from where the tripod thumb screw comes through the lower board. A hole, 1⅝ inch in diameter, is cut into the lower board, for the head of the thumb screw in the upper board, so that two boards may be folded together. The object of placing the thumb screw holding the camera so far back is to provide means for getting at both thumb screws at the same time, no matter what the position of the camera. A piece of cotton flannel cloth is glued to the top of the upper board to avoid scratching the camera base, and to prevent slipping. The bracket is easily carried fastened to the tripod, and provides the cheapest and most useful camera bracket the writer has ever seen.—Machinery.

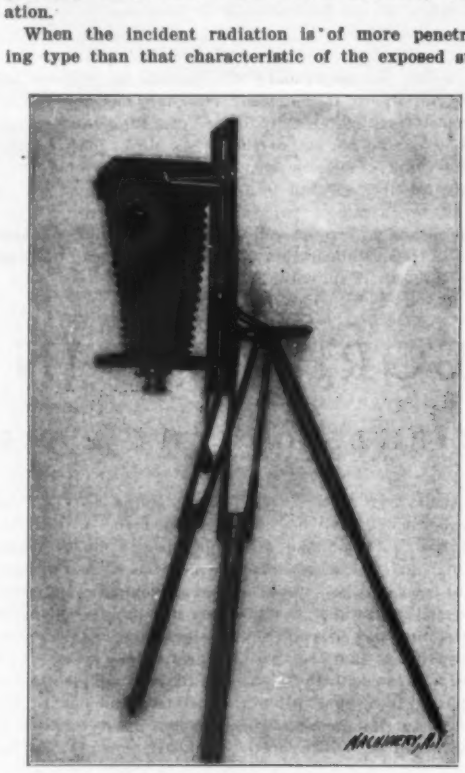


FIG. 4.—CAMERA HELD IN VERTICAL POSITION ON BRACKET.

THE ABSORPTION OF X-RAYS.

THE results of experiments that have been made by a number of investigators on the absorption of X-rays, secondary X and γ rays, are so complicated by a variety of conditions that few general conclusions can be drawn from them. It is apparent that a knowledge of the simple laws governing the absorption of X-rays, and the emission of secondary rays, would in many cases enormously simplify the explanations, and save much fruitless labor.

By the use of homogeneous beams of X-rays, and by a study of secondary X-rays, we have been enabled to arrive at the following conclusions:

Many elements—possibly all—when subject to a suitable Röntgen radiation emit at least one homogeneous beam of X-radiation, which is characteristic simply of the substance emitting it.

When a radiation which is of more absorbable type than the radiation characteristic of a certain substance is incident on that substance, it does not appreciably excite that characteristic secondary radiation.

When the incident radiation is of more penetrating type than that characteristic of the exposed substance, that characteristic secondary radiation is excited.

The absorption of the radiation not sufficiently penetrating to excite the homogeneous secondary radiation characteristic of an absorbing element is governed by very simple laws, the ratio of the absorption coefficients in elements A and B (say) being constant. That is, λ_A/λ_B is approximately a constant for any radiation experimented upon which is not more penetrating than the radiation characteristic of A or B.

When the incident radiation is of more penetrating type, the absorption is greater than would be given by this law, additional absorption being evidently essential to the emission of the characteristic secondary radiation. As the general penetrating power of the incident radiation increases, the intensity of secondary radiation increases, and the absorption by this particular element increases, and finally for more penetrating primary rays the intensity of secondary radiation and absorption of primary rays decrease again in the ordinary way.

The beam emerging from the absorbing plate consists of a weakened primary beam proceeding in its original direction, a little scattered radiation, and a homogeneous radiation uniformly distributed (except for internal absorption). There is no evidence of any other kind of transformation—speaking purely of X-rays.

We may, therefore, by a proper choice of primary radiation and absorbing element observe any of the following:

(1) Incident and emergent beams of identical penetrating power.

(2) Incident beam, homogeneous; emergent beam a mixture of two homogeneous beams, the ratio of the intensities of which asymptotically approaches a constant value, as the thickness of the absorber increases.

(3) Incident beam, homogeneous; emergent beam a mixture of two, the radiation of incident type ultimately vanishing and leaving a completely transformed radiation.

A homogeneous radiation from an element appears specially penetrating to that element and to elements of neighboring atomic weight, because it is of less penetrating type, or only just more penetrating than the radiations from these elements.

The change in the character of an ordinary heterogeneous beam of X-rays in transmission through an element is due to (1) the general selection of rays of the more absorbable type; (2) the special selection of those rays of greater general penetrating power than the radiation characteristic of the absorbing substance; (3) the emission of secondary rays, which are more generally absorbable than the radiations which produce them, but which may be more penetrating to the element emitting them.

The energy of primary radiation transformed into secondary rays is so great that the secondary X-rays proceeding from the antikathode of a Röntgen tube constitute a considerable portion of the heterogeneous beam.

Many of Mr. Kaye's experiments on so-called primary rays, for example, are obviously experiments on secondary rays, verifying our previous results. A comparison of the absorption coefficients shows the identity of the two.

A fuller treatment of the subject of absorption will shortly be published. We wish, however, to point out the great simplification that results from the application of these simple laws to many of the phenomena which have recently been described in a variety of papers on X-rays and secondary X-rays. Probably the laws may be extended to include also the γ rays.—C. G. Barkla and C. A. Sadler in Nature.

FIG. 1.—UNIVERSAL CAMERA BRACKET OF SIMPLE DESIGN.

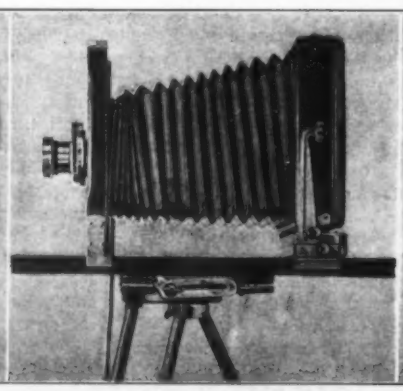


FIG. 2.—CAMERA MOUNTED IN HORIZONTAL POSITION IN BRACKET.

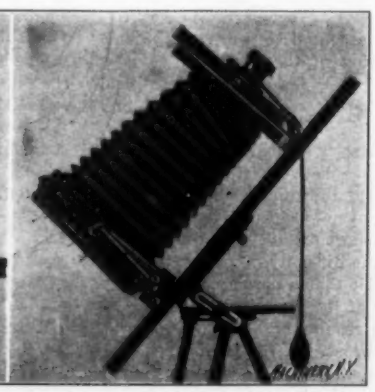


FIG. 3.—CAMERA MOUNTED IN AN INCLINED POSITION.

Acetic aldehyde, formed by oxidation of alcohol owing to exposure to the air, occurs in wines and brandies in varying proportion, which seldom exceeds one part in 5,000. The quantity of aldehyde is increased by aeration, agitation, aging, and the microorganisms of "sick" wines. The aldehyde gradually disappears in various ways. Some of it combines with the coloring matter and is precipitated normally in the process of aging, abnormally in diseases of wine caused by bacteria and diastases. By prolonged oxidation part of the aldehyde furnishes a portion of the acetic ether which contributes to the bouquet of all wines. Acetic ether and its compounds with alcohol (acetals) assist in the yellowing of old wines and brandies. Finally, aldehyde and acetals may assume polymeric forms, giving rise to resinous bitter principles. Acetic aldehyde appears to play some part in all the important changes which wines undergo.

A BRIEF HISTORY OF THE DOUBLE BASS.

THE DEVELOPMENT OF THE LARGEST OF STRINGED MUSICAL INSTRUMENTS.

BY GIUSEPPE MARIA MARANGONI.

THE origin of bow musical instruments is shrouded in obscurity. It is claimed by some musical historians that the violin was brought from the East to Europe by the Crusaders. By many writers the Ravanastron, a twelfth-century instrument which was played with a hair bow, is regarded as the prototype of the modern bow instrument. The East Indians were apparently familiar with it even in ancient times; for old instruments of theirs are to be found in the admirable collection of the Metropolitan Museum of Art in New York. The Ravanastron later found its way to other parts of Asia, so that it eventually became one of the most widely-played of Asiastic musical instruments.

Another group of historians maintain that the resonant body, neck, and the strings stretched over a bridge are all of occidental origin and that the prototype of the bow instrument is the *crouth* of the old English bards. It seems more probable, however, that the violin originated in the Orient.

The earliest known European instrument was the Rubeba, which is etymologically derived from the rebab of the Arabs, and played among them as early as the seventh century. The Arabs introduced the instrument into Spain at the beginning of the eighth century.

Although little is known of the origin of the violin, still less has been discovered of the beginnings of the double bass. Indeed, the history of every member of the violin family, with the exception of the double bass, is more or less known. No stringed instrument is subject to such diversity of opinion as regards tuning, fingering, and the form of bow with which it is played.

So far as I have been able to ascertain, the double bass was patterned in early times after the *violone* of Ganassi. This prototype of the double bass is here reproduced from Ganassi's work "Regula Rubertina," published in Venice in 1542 and dedicated to Neri Capon. A copy of the book is to be found in the library of the Bologna Musical Lyceum and in the Royal Musical Institute, Florence.

Ganassi's *violone* was of peculiar form. It had six strings and a fingerboard with ten frets, which, like those of the guitar, simplified stopping when difficult passages were played. The neck of the instrument was like that of a large guitar.

The instrument was first introduced in the orchestra by the composer Jacopo Peri in the production of his opera "Eurydice" in 1608 in Florence.

In the museum of the Paris Conservatory is a gigantic contrabass built by the celebrated maker Vuillaume. It is 4 meters (13.12 feet) high. Its range extends to the double low octave of the 'cello; that is to say, an octave lower than the modern double bass. It has four strings tuned in fifths and fourths. As the fingers of a man were not strong enough to stop the strings, Vuillaume provided a stopping mechanism composed of several steel knobs, constituting mechanical fingers, which heavily pressed on the string. In addition to this mechanism he provided a pedal with which he increased the pressure on the strings. With this huge instrument a tone of larger volume than that given by the modern contrabass was obtained.

In Boston, Mass., a certain Steinert constructed in 1882 an aluminium double bass upon which he spent a good deal of time and money and then sold it to a manufacturer of instruments who exhibited it as an advertisement of his instruments in the window of his own shop. Lightness of construction was his object.

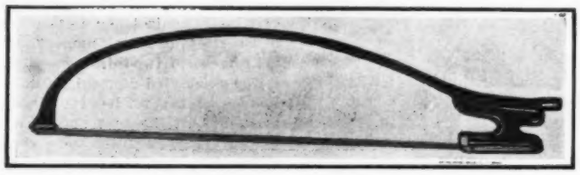
In Perugia and at the beginning of this century, the Mariscal Vito Vitaliano, a native of Reggio, in Calabria, southern Italy, built a double bass with two bodies. In other words, he placed one instrument inside of another, the outer casing having an oval aperture. Vitaliano thought that in this double body the sonorous waves acquired a larger amplitude, and that consequently the instrument would produce louder tones. In actual practice the instrument failed to realize the inventor's hopes.

Beside these makers, others have tried to give new forms to the contrabass. Nevertheless, the instrument still retains its classical form.

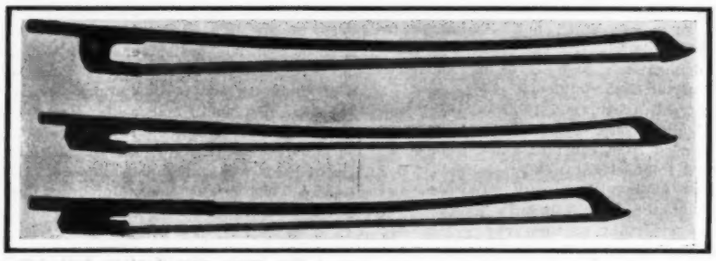
The Duke Wilhelm Moritz of Saxony, who lived in the first half of the eighteenth century, was an enthusiastic admirer of the double bass, and he had a private museum of double basses in his castle of Merseburg. In the center of the hall was an enormous instrument, which could be played only by ascending and descending a stepladder.

Prof. Chevalier Gandolfi (librarian of the Royal Musical Institute of Florence) in his "History of the Origin of Bow Instruments" mentions a double bass nine feet high, painted by Paolo Veronese in his picture "Le Nozze di Canaan" ("The Marriage at Cana"). Consequently, we must believe that in the sixteenth century there were large bow instruments.

Many attribute the invention of the double bass to Michele Todini of Saluzzo, who worked in Rome in the seventeenth century. This is wrong, because To-



THE BOW USED IN GANASSI'S TIME.



THE GERMAN BOTTESINI AND FRENCH BOWS IN USE AT THE PRESENT TIME.

GANASSI'S VIOLONE, THE PROTOTYPE OF THE MODERN DOUBLE BASS.

VUILLAUME'S DOUBLE BASS. THE INSTRUMENT WAS PROVIDED WITH MECHANICAL STOPS ACTUATED BY PEDALS.

DOUBLE BASS IN THE WILHELM MORITZ COLLECTION. IT WAS SO LARGE THAT THE MUSICIAN HAD TO USE A LADDER TO PLAY IT.

dini, in a pamphlet pompously called "Dichiarazione della Galleria armonica eretta in Roma da Michele Todini," etc., flattered himself with having introduced the large *violone* or double bass in the orchestras of Rome, but he did not claim the credit of its invention. Other biographers state that the true inventor of the double bass was a distinguished player named Monteclair. This is also wrong, because he introduced it in 1700, after Todini, in the orchestra. It seems that there was but one double bass in the orchestra which was played every Friday for some particular reason.

After Monteclair, Gossec introduced two double basses in the orchestra, and Filidor, a French composer, employed three in the first representation of his opera "Ermelinda."

It must be stated that as early as 1636 the double bass was known in Germany and in Flanders. The writer saw in the Cathedral of Antwerp a double bass with a label reading "Peter Porion tot Antwerphem fecit 1647." The form of this instrument is quite primitive.

We must credit Todini with having improved the *arciviola* of Gasparo da Saló. He modified the neck, and reduced to four the number of strings, which, as we have already stated, were formerly six in number. The six-stringed instrument was thenceforth abandoned.

Todini was followed by the members of the celebrated Cremona and Bresciana schools, at the head of which was the great Stradivarius. Todini constructed true double basses, which are now very rare and of immense value.

Several historians state that the celebrated Antonio Stradivarius (Cremona, 1644-1737) made contrabasses. Not one has been handed down to us. The writer doubts whether Stradivarius ever made double basses. There seems to be no record of any specific instruments made by him.

Among the best makers of the double bass must be mentioned Carlo Bergonzi (Cremona 1716-1747), who is considered to be the best pupil of Stradivarius. He built splendid double basses.

Niccolo Amati (Cremona 1596-1684) is also a famous maker, but his instruments are rather small and not so good as Bergonzi's.

Santo Maggini (Brescia 1590-1640) distinguished himself greatly in the construction of double basses, especially by the peculiar form that he gave them and by the beauty of their tone.

Giuseppe Guarneri, who was called Del Gesù to distinguish him from his cousin Giuseppe di Santa Teresa, worked from 1683 to 1745. His instruments are very much sought after.

Domenico Montagnana (Venice 1690-1750), a favorite pupil of Niccolò Amati, constructed very fine instruments. They were generally large and of penetrating tone.

Carlo Giuseppe Testori was the best pupil of Cappa di Saluzzo. He worked up to the beginning of the eighteenth century. His instruments are excellent, especially for concerts. The celebrated virtuoso Bottesini used to play on one of his double basses.

Giacomo Steiner (Abson 1620-1683), of the Tyrolean school, distinguished himself greatly in the construction of the double bass, especially by the amplified form which he gave it and by substituting a lion's head for the scroll.

Francesco Gofriler (Venetian school, 1690) made wonderful instruments that are in great demand. They are generally varnished yellow and are of a very sweet tone.

Bachmann, in the year 1715, introduced the mechanical peg for holding and tightening the string. His instruments were excellent.

Francesco Busas (Venetian school, 1740) made beautiful double basses of exquisite sonority.

Lorenzo Storioni, who worked at the end of the eighteenth century and the beginning of the nineteenth, constructed instruments highly appreciated and according to the school of Amati.

Giambattista Guadagnini (Cremona, 1711-Turin, 1786), a pupil of Stradivarius, made excellent instruments, well finished in all their details.

Antonio Casini (Modena, 1730-1760) constructed very good double basses, carefully finished in dark red, and of a very sweet tone.

Those of Santo Serafino of Udine, who worked in Venice in the eighteenth century, are well thought of; also those of Lorenzo Carcassi, of Gabbrielli, and of Piatellini, who worked in Florence during the eighteenth and nineteenth centuries.

Pietro Rogeri, who lived in the eighteenth century, constructed wonderful double bases, whose very correct forms show his skill. The body is elongated, varnished almost yellow, very sonorous in the low notes. The instrument of the writer is constructed by him, and is most beautiful.

The instruments of Gasparo da Saló were very fine. As stated, these were *arciviole* in the beginning, and were transformed into double basses by the modification of Todini, who gave them a neck. According to the Marchese de Piccolellis, Saló worked in Brescia from 1550 to 1615, and during sixty-five years constructed a large number of instruments, which time has destroyed.

FAMOUS PLAYERS OF THE DOUBLE BASS.

With the great number of famous players who since the middle of the last century up to our day have added to the glory of the double bass, has commenced a new era in the study of this instrument. Great virtuosi of the double bass have played at the principal courts of Europe; in the most celebrated theaters, and the *salons* of amateurs, evidencing not only the wonderful artistic execution that can be obtained with the double bass, but also that the instrument can victoriously compete even with the 'cello.

The Austrian Knempfer was particularly skillful in drawing harmonic and high-pitched tones from this instrument. His execution was wonderful. He played with great feeling, with ease, elegance, and without the least sign of fatigue. In order to carry his concert instruments taken from one place to another, he had a removable neck made, to reduce the size of the instrument to two-thirds.

The celebrated Domenico Dragonetti (Venice, 1763-London, 1846) rendered with wonderful agility the most difficult passages and of almost insuperable intervals. His andantes were charming, and his tone rich and mellow. In order to give an idea of his wonderful execution, although I doubt the truth of the story, it is said of him in "Ancient and Modern Violin Makers" by the Marquis Piccolellis, that Giovanni Battista Viotti, who liked to tease Dragonetti, once proposed to him in a company of friends to play with him one of his most difficult compositions, a duet for two violins, Dragonetti to play the part of the second violin on the double bass. According to the story, Dragonetti accepted, and on his Saló instrument played the difficult part for the instrument for which it was composed, in a wonderful way and as if it had been an easy composition. Although the audience was surprised, Viotti not wishing to be beaten, proposed to his friend to change parts; Dragonetti accepted immediately, and played on his instrument the part of the first violin.

Giovanni Bottesini (Crema, 1821-Parma, 1889) was the greatest of all players. His technique was wonderful. He traveled from court to court, from country to country, from city to city; idolized everywhere, he was distinguished with the name of the "Paganini of the double bass." We have no space to give a biography of this great genius, not only the greatest of all players of the instrument, but also great as a composer and a conductor. He was so noted as a conductor, that Verdi chose him to direct the first representation of his opera "Aida" at Cairo. The double bass players of the Cairo orchestra showing some diffidence in playing under such a celebrated master of their instrument, he said to them, "You have nothing to fear from me. I am well aware of the difficulties of the instrument, and I will help you out to show your ability." I advise admirers of this instrument to read his biography by Cesare Lisei, published by Ricordi of Milan.

CHANGES IN THE DESIGN OF THE DOUBLE BASS.

In the beginning the instrument was played with four strings, and at the beginning of the nineteenth century, in France and in Italy, the fourth string was dropped. Only the Germans, always conservative and never easily moved by fashion, scrupulously preserved the old form of the instrument. They are right; because in the instrument thus mutilated, many compositions lose their original beauty, and the player is compelled to edit them in a grotesque manner.

Achille Gouffé, a very distinguished player, was the first to compel French players to use the fourth string. Some time afterward, Verdi, at the first hearing of his opera "Othello," at the Scala Theater of Milan in 1887, made all the artists play on the instrument of four strings, in order to render the solo of the fourth act, which simultaneously with the appearance of the tenor, serves to impress the audience with the tragic and passionate character of the opera.

The greatest composers have availed themselves of the double bass in descriptive composition. Thus Beethoven in his Pastoral Symphony employs the rumbling of the double bass to depict the roaring of a storm.

Wagner, in the third scene of the third act of "Lohengrin," employs the double bass in a rapid treble passage to produce the effect of galloping horses.

Feliciano David, to depict the calm of the desert, uses the low tones and long sounds of the double bass.

Richard Strauss, in his opera "Salomé," uses the double bass to set forth the tense moment when the executioner with his scimetar beheads the unfortunate prophet.

Mabellini, in order to depict the terrible appearance of hell, which opens the second part of his cantata "Lo Espirito di Dante," employs with great effect four double basses in harmony.

Mascagni, in his opera "Iris," uses the double bass as a solo instrument, and thus admirably depicts the waning of twilight and the dawning of a new day, which is followed by a beautiful musical passage of luxurious instrumentation in praise to the sun.

The double bass is an instrument of great importance. It requires a serious and systematic study. It is not a joke, as many think. The writer has heard the instrument recommended to amateurs who could not distinguish themselves in playing any other instrument. Some people regard the instrument as the *refugium peccatorium* for those born without any musical talent, thus ignoring the great natural ability required from those who wish to play it well.

The double bass is undergoing a transition in our time, largely because of the demands which the modern composer makes upon it. Richard Strauss, Korsakov, Debussy, Gevaert, etc., arrange their scores for five-string double basses. Indeed, the five-string instrument is already used by the Philharmonic Society of Berlin, in the Brussels Conservatory, and even in the orchestra of the Metropolitan Opera House of New York. To the writer's mind this is a great mistake. The lower the musical tone, the less is the number of vibrations required to produce it. A tone ceases to be a musical tone when the ear perceives the vibrations. Then we have simply noise. The fifth string will produce in the most perfect ears an effect between tone and noise, which cannot be pleasing. Besides, the larger the number of harmonics of a chord, the more sonorous it is; and if from this point of view the fourth string is not altogether perfect, the fifth will be less so. If we are to increase the number of strings, why stop at five? Why not go back to the original six-stringed instrument?

THE BOW AND HOW TO HOLD IT.

The form of bow still causes much dispute. The primitive form used by Ganassi and afterward by Saló was markedly concave. It was generally used up to Dragonetti's time, and was held with the hand turned upward. Time and evolution have proved that this form of bow is defective, because it is too short, too arched, and not flexible enough. The Germans improved this form of bow, but followed the old way of holding the bow. The German bow is curved like the bow of a violin and 'cello. Because the German players still hold the bow in the old fashion, the tone is harsh, especially in concert playing. It is not possible to obtain very delicate tones with this manner of wielding the bow. Moreover, the old way is not æsthetic, and the concert artist can never assume an elegant pose, as when he plays with the French bow improved by Bottesini. Bottesini lengthened the bow, and it is his bow which is always used in France. With such a bow Bottesini obtained protracted tones in playing adagio passages. The Bottesini bow has the advantages of the old and of the German bow, and according to the writer's opinion it is the best, differing from the 'cello's bow only in being better suited to the double bass.

The French and Italian players hold the bow with the hand turned downward, which is the way of holding the bows of all other instruments. There seems no good reason why the method should not be adopted, particularly since a better tone quality is obtained, and the player's position is more pleasing to the eye.

WHY STEEL RAILS BREAK.

THE presence of manganese sulphide is one of the many causes to which the breakage of steel rails has been attributed. This compound was found in manganiferous steel in 1885, and afterward in steel rails, in the form of dark gray masses. These discoveries have since been confirmed by the microscopic examination of steel to which manganese and sulphur had been purposely added. All doubt as to the chemical nature of the gray matter has been removed by Fay's recent experiments, in which manganese sulphide was melted with iron in an electric furnace, in such proportion that the mixture contained 0.08 per cent of sulphur. The dark gray matter was found scattered through the cooled metal. Its chemical character was not open to doubt, since the metal contained only iron and pure manganese sulphide. Manganese, if present in sufficient quantity, combines with the greater part of the sulphur in steel. Any iron sulphide that remains undecomposed is disseminated through the metal in minute grains which are no more injurious than so many minute gas bubbles. Steel containing ½ per cent of sulphur, but no manganese, can be forged perfectly. The effect of manganese sulphide is very different. This compound melts at 2,124 deg. F., 500 deg. below the fusing point of steel. Hence if the steel is rolled at a very high temperature the little masses of manganese sulphide are fused and spread out into thin layers of elliptical or elongated shape which ultimately give rise to fissures. The obvious inference is that the steel which contains sulphur and manganese should be rolled at a comparatively low temperature at which manganese sulphide remains solid.

CHEMICAL AFFINITY.*

ITS RELATION TO ELECTRICAL ATTRACTION.

BY SIR OLIVER LODGE.

ONE of the salient discoveries of the last century, on which sufficient stress is seldom laid, is the discovery that chemical affinity and electrical attraction are one and the same—that the electric force between charged bodies is really chemical action at a distance, and that the chemical combination of atoms and molecules is due to their electrical attraction. Even what is called residual affinity, or latent valency, or molecular combination, can be thus explained also; for the "bond" of the chemist is thus seen not to be an invisible unit, but to be made up of a bundle of lines of force, some of which are available for taking hold in a number of minor directions. And thus the phenomenon of "mass-action" becomes completely intelligible. And in this same way the at-first-sight surprising dissociation of salts, by the mere fact of dilute solution, is explained likewise. The fact of physical cohesion, the linking together of saturated chemical compounds into a mass with mechanical tenacity, the whole subject of "strength of materials" in fact, seems explicable also on this doctrine of residual affinity or subordinate electrical attraction between molecules. For tenacity, though great enough in the aggregate, is a small force per unit, and is incomparably smaller than the forces specifically known as chemical. Just as gravity, though eclipsing them all when planetary masses are concerned, is trivial when compared with cohesion for bodies of ordinary size, and is practically infinitesimal among atoms and molecules.

For a first instance of this, take the gravitational attraction of earth and moon: the force needed to hold the moon in, while whirling round the earth once a month, would tear asunder a steel rod 400 miles thick. For a second instance take the tenacity of 30 ton steel; holding itself together with a force of 30 tons weight per square inch, or, expressed in C. G. S. measure, $\frac{30 \times 10^9}{6.5}$ dynes per square centimeter. Reduce this to the force across a molecular section, and it becomes $\frac{5 \times 10^9}{10^{16}} = 5 \times 10^{-7}$ dynes per pair of molecules. But if these molecules were electrically charged, and operated likewise at molecular distances, the force between them would be $\left(\frac{3.4 \times 10^{-10}}{10^{-8}}\right)^2 = 10^{-2}$ dynes per pair of molecules; which is 2,000 times as great. Not wholly incomparable therefore; but great enough to give the observed tenacity as a small outstanding or residual phenomenon.

Residual affinity need not be a mere indefinite appellation; it can be precisely defined. It represents the internal force between saturated molecules, holding a group of them together, condensing them into smaller compass than they would otherwise occupy, reducing their tendency to fly away from each other—condensing them in extreme cases into a liquid. It therefore produces the same sort of effect as external pressure produces, and it may be defined as equal to the external pressure which would produce the same condensation or compression on the same number of molecules of a perfect gas. A perfect gas has no residual affinity; its molecules are quite independent of each other. It does not, indeed, accurately obey Boyle's law as usually stated, because the molecules occupy a certain fraction of the whole volume—not all the space occupied is free; but it obeys the law, $p\ (v - b) = R\ T$, where b represents the aggregate molecular bulk, reckoned as cubes not spheres. An imperfect gas or vapor, however, with a residual affinity, K, obeys the law, $(p + K)\ (v - b) = R\ T$. And this K is known as "Laplace's molecular pressure" or internal force. But K is not constant; it increases with the square of the concentration; hence by Van der Waals it was written as $\frac{a}{v^2}$, thus giving us the famous and well-known Van der Waals's expression, which more or less approximately embodies the properties of gases, vapors, and liquids. A measure of K can be made by compression experiments, though of course in any substance for which K is great the compressibility is small. A first approximation is the incompressibility or elasticity of volume, that is vdp/dv; but this is mixed up with the quantity b, and so K is not to be disentangled by incompressibility alone. A better mode of estimating it is by the energy of disgregation of a liquid; in other words, by the work that is needed to pull the molecules asunder from their cohesive attraction—that molecular attraction which has liquefied the substance—and to scatter them as vapor; in other words, by determining the latent heat of evaporation. For instance, at t deg. C. this is well known to be for water $607 - 0.7t$ calories per gramme, and interpreting this in energy units by multiplying by J (that is, by 4.2×10^7), it becomes, for water near the ordinary boiling point, $540 \times 42 \times 10^6 = 23{,}000 \times 10^6$ ergs per cubic centimeter, that is, $23{,}000 \times 10^6$ dynes per square centimeter or 23,000 atmospheres, or a quantity of that order of magnitude. No wonder then that there should be both chemical and physical evidence that in the liquid state water molecules are liable to cling together into prodigious aggregates and that the substance has a remarkably high specific inductive capacity.

An increase of molecular cohesion tends to raise the boiling point, and likewise the surface tension, as in the case of mercury. The critical point likewise depends largely upon the value of K; and if K is zero liquefaction is impossible.

The smallness of residual affinity between the molecules of helium and other members of the argon group of gases explains why they so strongly resist liquefaction; but whether they liquefy or solidify first, depends of course merely on whether their boiling point is above freezing point or not. In a vacuum, the freezing point of water is above its boiling point, and accordingly, in a vacuum, ice only evaporates and does not liquefy: an observation made by Carnelley. To liquefy helium, the pressure would have to be increased; though whether it would be possible to do it then remains to be seen. It would be more easy to try the experiment first with neon. (See A. W. Porter, Nature, 12th March, 1908.)

But how can we measure the residual affinity or molecular cohesion for a thing not in the liquid or the solid form? How can we measure it for a nearly perfect gas? Joule and Thomson devised a way. The gas is cooled and compressed as much as possible, so as to give the molecular attraction every chance; and then suddenly let go, the cold of expansion being observed. If the pressure could really be reduced suddenly to zero there *need* be no cooling, because then no work of expansion would have to be done. All that would then be observed would be the residual cooling due to the molecular attraction. But as this is impracticable, the plan adopted must be to compare the cold of expansion with the heat of compression, and see if they are the same. If, when a gas expands, say to double its volume without doing any work, the temperature is the same after expansion as before—when local eddies and rushes have subsided—the gas is a perfect gas, and Laplace's K or Van der Waals's $\frac{a}{v^2}$ is zero. For such gases as hydrogen and helium this is very nearly true, but not quite; and it is this residual affinity or molecular cohesion which in the last resort must be depended on to liquefy or solidify them. All liquefaction depends upon this term, and upon nothing else. External pressure cannot do it, for directly that is relieved the compressed gas completely recovers. But if there is any trace of molecular cohesion, then it exhibits signs of imperfect elasticity, or a more or less permanent set. It is most noticeable when the concentration is excessive, for, as said before, it depends on the square of the concentration, $K = A\beta^2$.

This is the basis of Lord Kelvin's determination of absolute zero. A perfect gas without cohesion would obey the law $p\ (v - b) = R\ T$, and the temperature at which its pressure became zero would be the absolute zero. At any temperature above that its molecules would have some movement, and would accordingly by bombardment exert some pressure.

The absolute temperature would be the reciprocal of its coefficient of expansion per degree at constant volume, $T = p\frac{dT}{dp}$, and could be so measured. But as no such gas exists, experiments have perforce to be made on an imperfect gas, and a correction applied for the amount of its imperfection. In this way Joule and Thomson determined that the absolute zero lay between 273 deg. and 274 deg. C. below the freezing point of ordinary water; more exactly, it came out 273.2 deg.—a determination which has a real and living interest now that Dewar and others are constantly working down to within a small number of degrees above this ultimate limit, below which it is impossible to go.

It must be forever impossible, because at that temperature bodies possess no heat, and therefore cannot have any removed. I do not say that the atoms possess no energy—far from it—their energy of internal constitution need not necessarily have been affected; but they possess none of the unorganized energy of molecular motion which we call heat: each molecule, as a whole, at absolute zero, is at rest.

THERMOPHILE LIFE.

FOR the great majority of organisms the upper temperature limit is 40 to 45 deg. C. (104 to 113 deg. F.). There is, however, a small group of microbes, so-called thermophile forms, which not only resist considerably higher temperatures, but which are actually incapable of growing at ordinary temperatures, such as are ordinarily considered favorable to life. According to H. Miehe we can distinguish four classes of such organisms. The first he terms thermophile organisms proper. These show little or no growth at temperatures of 25 to 30 deg. C. (77 to 86 deg. F.) Among them are tubercle bacilli, the germs of diphtheria and influenza, and a number of fungi. The second class, so-called ortho-thermophile organisms, are distinguished by their remarkably high optimum and maximum temperatures, the former ranging from 50 to 60 deg. C. (122 to 140 deg. F.), the latter from 70 to 75 deg. C. (158 to 167 deg. F.) To this class belong *Bacillus calfactor* and *B. robustus*. Another group, while flourishing favorably at ordinary temperatures, have a comparatively high maximum, viz., about 50 deg. C. (122 deg. F.) These are spoken of as thermo-tolerant, and include among others the bacillus of hay-infusion. Still another class have a comparatively high optimum (40 deg. C. or 104 deg. F.), but nevertheless multiply in some measure at lower temperatures. These, which include many pathogenic bacteria, are spoken of as psychro-tolerant (psychros = cold).

These thermophile organisms—using the term in the broader sense to comprise the four separate types distinguished above—are found in a great variety of places, but only in comparatively rare cases under conditions which would account for their peculiar properties, namely, in hot springs. For while certain algæ do grow in such springs, there is on the whole very little organic matter present, such as would offer a suitable medium for the growth of bacteria. If we regard the properties of organisms as the result of adaptation, the problem arises, what is the natural home of these thermophile—and especially of the ortho-thermophile—organisms? The case of pathogenic bacteria alone could be accounted for in relation to the body temperature of the animal host. The only imaginable case of a suitable environment for ortho-thermophile organisms is that of accumulations of vegetable matter undergoing slow spontaneous combustion. And apparently in this case it is the organisms themselves that give rise to the conditions on which their life depends. It would seem that the ortho-thermophile organisms must be regarded as products of civilization, since the conditions for spontaneous rise in temperature will hardly occur except in technical and agricultural installations. The sun's heat cannot have been a factor in the development of the life-habits of these organisms, since it is inseparably associated with light and drying action, each of which is distinctive to low forms of life. The high temperature required by disease germs is evidently a case of adaptation to body temperature. Whether these organisms also occur in nature under other conditions is an open question. Quite inexplicable is the case of the spores of *Bacillus subtilis*, the germ of hay-infusion. These spores, which are attached to the hay, actually resist a boiling temperature for several hours.—Prometheus.

Malt Coffee.—According to the Pochat patent, malt, freed from rootlets, for the purpose of saccharification and extraction, is treated in the manner known in distilling as the thick-mash process. After the grains have been separated from the work by straining, the latter is concentrated by evaporation and mixed with sugar. This mixture is then rubbed down, after the addition of a fatty substance, for instance cocoa powder not deprived of fat, which is thoroughly mixed with the roasted grains, as well as with previously roasted malt kernels, deprived of their bitter substance.

* Abstract of a lecture read before the Society of Chemical Industry.

INCREASING THE SOIL'S NITROGEN CONTENT.

THE BOTTOMLEY SEED AND SOIL NITROGEN BACTERIA FOR LEGUMINOUS CROPS.

BY OUR ENGLISH CORRESPONDENT.

DURING the past few years the scientific treatment of soils and seed to secure increased yields of crops has undergone considerable development. Since Beyerinck obtained his pure culture of the root tubercle organism on artificial media which he named *Bacillus radicicola*, several botanical scientists have followed up the problem. At first much difficulty was experienced in fixing the culture so that it could be kept for varying periods without deterioration. The Department of Agriculture at Washington commenced investigations in 1901, and since 1903 large quantities of the medium have been distributed throughout the country. To enable the nitrogen-fixing organism to retain its vitality for a sufficient time it was dried on cotton wool, but this method proved unsuccessful for commercial purposes, and now the pure cultures are sent out in liquid form in bottles.

Such a system, however, has disadvantages, especially in regard to transportation and handling. Drying on cotton wool having failed, W. B. Bottomley, professor of botany in King's College, London, directed his energies toward the discovery of a preservative. His experiments resulted in the production of a powder preparation of the bacteria insuring vitality for at least two years. It not only acts as an excellent preservative, but appears to strengthen the organism very appreciably, and is capable of imparting the requisite nitrogen to soils generally considered to be unable to sustain plant life. For instance, an excellent crop of Mexican beans was grown in volcanic ash merely by the addition of the solution of the culture to the ash. In another instance inoculated sweet peas were grown in cinders and yielded a free and luxurious mass of bloom. At the same time the professor shows that there are soils whose physical properties are unfavorable to plant life, and no amount of inoculation can remedy the deficiency. Soil acidity, insufficiency of phosphate and potash foods and improper drainage are all conditions which resist the advantages of inoculation. The bacteria can only perform their work so long as there are sufficient quantities of phosphates, potash, or lime present in the soil, since these nodule forming bacteria only supply nitrogen.

"Nitro-bacterine," the name of the culture, is easily prepared. There are three packets. One contains the bacteria, while the other two are the various chemicals necessary to impart life and vitality to the microbes. In making the solution cleanliness must be observed in the vessels in which the liquid is prepared, so that the bacteria may not be affected by other microbes. The first packet contains specific salts that are first dissolved in a gallon of cool, preferably sterilized rain water. The contents of the second package, the powdered bacteria, are added and well stirred. The mouth of the vessel such as a pail or tub is then covered with a clean, moist cloth to secure protection from dust, and the whole kept in a warm place, for instance, near the fire, where the temperature of the solution will not exceed 75 to 80 deg. F. After being stored in this condition the contents of the third package are added and similarly dissolved. Revitalizing of the bacteria soon commences, and after being left quiescent for a short time the solution becomes cloudy, showing that the microbes are active and multiplying. Cloudiness generally occurs in from twenty to thirty-six hours if the temperature conditions are suitable. If, however, the temperature has been too low, growth and multiplication are somewhat retarded, and a further period should be allowed not exceeding two days to produce the requisite cloudiness, since unless this develops the solution is useless. Should too long a period elapse between the addition of the third package and its use, the solution becomes deteriorated owing to the teeming millions of bacteria having succumbed on exhausting the nutriment.

For the purpose of inoculation, the cloudy solution can be sprinkled gently over the seeds, care being observed to turn them over from time to time so that all parts may receive an equal quota of the liquid, or they can be dipped in the solution, but not soaked. When thoroughly moistened they are left in a dry place, where sunshine cannot enter. The result is that the microbes, thousands of which cling to every seed, become transformed into a state of suspended animation. When dry, the seeds can be gathered and either planted in the usual manner at once, or stored away until the planting season, since the organisms will retain their fertility for several months, but the sooner sowing takes place the more certain the yield.

The immersion of the seeds in the soil resuscitates the bacteria, which being extremely hungry, attack the roots of the plant and expedite the process of germination. Immediately a blade of green appears above ground, the colony of microbes below commences drawing continuous volumes of nitrogen from the air, and plant growth is accelerated and strengthened.

To complete the stimulation, the soil around the inoculated seeds should in turn be dressed with the same medium. This can be carried out in two ways —either in the form of a fertilizer or by sprinkling. For the first, equal proportions of the cloudy solution and water are mixed together. This is poured into a sufficient bulk of dry soil to insure every particle of soil becoming moistened. One part is then combined with four or five parts of soil, the whole thinly distributed over the crops the same as ordinary fertilizer, and raked or harrowed in. If used as a top dressing the powder should be applied in showery weather so that the bacteria may be washed down into the soil around the roots. For use in watering, one part of the solution is combined with fifty parts of water, and the whole applied with a can or hose. The tests made have proved most satisfactory, and the cost of the second operation is trifling.

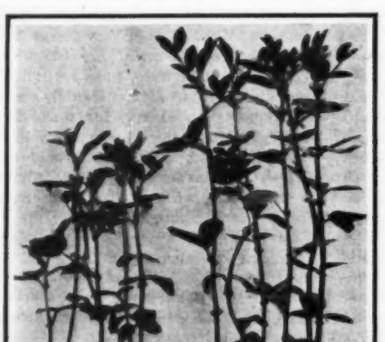
Prof. Bottomley finds that different crops should have specific cultures to secure the maximum results. That is, various beans need a distinctive culture from that applied to indigo, clover, peas, etc., the culture for the last named similarly calling for specific and individual cultures. He has succeeded in standardizing the necessities of these varying crops with the result that the demand for any type of leguminous crop or forage plant can be fulfilled.

Prof. Bottomley distributed the powder among farmers throughout the British islands for the purpose of testing it upon cultivated and sterile or barren soils. The results were curious, though showing uniform improvements in the yield and value of the produce. In Ireland an attempt was made to reclaim a tract of waste cut-away bog-land covered with heather. The area selected was first given a top dressing of a mixture of kainite and superphosphate, about 560 pounds to the acre. Four months later inoculated seeds of grasses and red clover were sown and followed by a top dressing of soil in about the same proportion as that of the artificial fertilizer. In two months the curious combination was observed of grass, clover, and heather growing thickly together with here and there patches of rushes and bent. Growth from the inoculated seeds soon overtopped the heather. Before harvesting, it was found that the heather, rushes, and other useless vegetation had been choked by the luxuriant product of the inoculated seeds, and were dead at the lower part of their stems, so that the scythe could be easily used. After mowing, the grasses sprang up thicker than ever, preventing the penetration of the heather shoots, and in the following year a wealthy crop of rich hay was obtained. At present there are no signs of the heather and useless vegetation reappearing, the herbage being too rich and dense to offer a passage for the shoots of the former, which have since died. The experiment shows that many barren areas might be similarly reclaimed, as nothing need be spent on tillage. For reclaiming sandy wastes it might be utilized to advantage since the professor has demonstrated the possibility of raising crops in sand simply inoculated with the nitrogenous bacteria.

Inoculated seed sufficient for from twelve to fifteen acres of land costs $1.25, while for the same price it is possible to spray one acre or more of crops. For purposes of securing reliable scientific data untreated soils have been used as a control in conjunction with the experiments. The average increase in yield has been 30 per cent as compared with the nitrated areas, and with an improvement in the quality, especially in beans and peas. In these tests leguminous crops of every description were grown, including various grasses. A small farm of poor soil, after twelve years' cultivation with manures and fertilizers without profit, was plotted out for the cultivation of crops comprising wheat, oats, clover, peas, etc. One-half of the oatfield was sown in the autumn, and the other in the following spring, the latter being sprayed with the culture when the blades were about two inches high. The difference between the two was very striking. The twenty-five acres of wheat were divided into sections. The first carried spring-sown wheat and inoculated grain, the rest being sown last autumn, one-half of which was subsequently sprayed, while the other was uninoculated, this last-named area in-

Lucerne Growing in Neighboring Fields. That on Right Inoculated; Left Not Inoculated.

Vetches Grown in Sand Field. On the Left Inoculated; Right Not Inoculated.

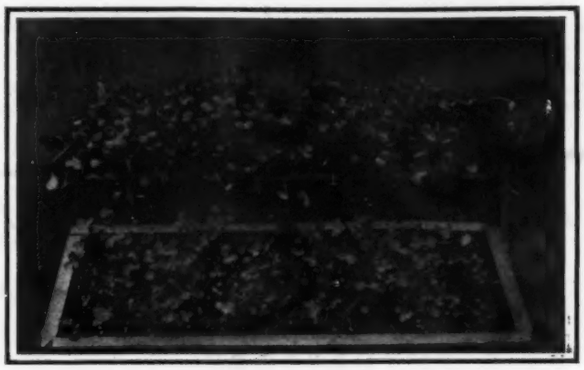


Broadbeans Sown at Same Time, Showing Comparative Growths.

Sweet Peas Sown at Same Time, Showing Advantages of Inoculation.

stead being treated with animal manure at a total outlay of $13 per acre. There was a general improvement in the inoculated crops with a gain of four bushels of grain to the acre. A similar improvement marked the clover tract, while the peas which had failed of cultivation upon the farm were completely successful. In the case of the beans six of the seven acres were inoculated, the remaining acre being reserved as a control. Prior to planting, three out of the seven were manured at a cost of $30 per acre. The yield of the inoculated showed an increase of 40 per cent, at a cost of $1.25 as compared with $120 for fertilizer. In some of the experiments it may be pointed out that the bacteria were two years old, which proves the efficiency of the preserving process.

Accelerated Germination Due to Inoculation; Sweet Peas Sown in Moss. The Inoculated on Right; Germination in 4 days. Non-inoculated, 7 days.



Clover After 54 Days' Growth. Top Box Inoculated; the Bottom Non-inoculated.

Inoculated Seed Sufficient for from Twelve to Fifteen Acres of Land Costs Only $1.25.

At a recent exhibition of the Royal Society of Great Britain photographs and growing specimens were shown, illustrating the inoculation of the roots of the leguminosæ. Some of these are pictured in the accompanying half-tones. It will be observed that the inoculation produces a marked increase of nodules on the roots, these lumps contributing materially to the growth of the plant by augmented extraction of nitrogen from the air, also that plant germination is appreciably accelerated as well as the growth, thereby enabling the produce to be gathered in a much shorter period.

Owing to this success, Prof. Bottomley endeavored to discover a culture for the treatment of non-leguminous crops. The tomato plant was selected, and at last he succeeded in finding a culture for this species. He has found cultures for roses and strawberries. The experiments with these are still in progress, with the aim of determining the precise bacteriological culture suited to every type of plant. While making no claim to the discovery of the action of these organisms, which were first ascertained by Hellriegel, Prazmowski, and Nobbe, he has continued the work from the point where the last named failed to discover a preserving medium.

IS THERE A TRANS-NEPTUNIAN PLANET?

By F. W. HENKEL, B.A., F.R.A.S.

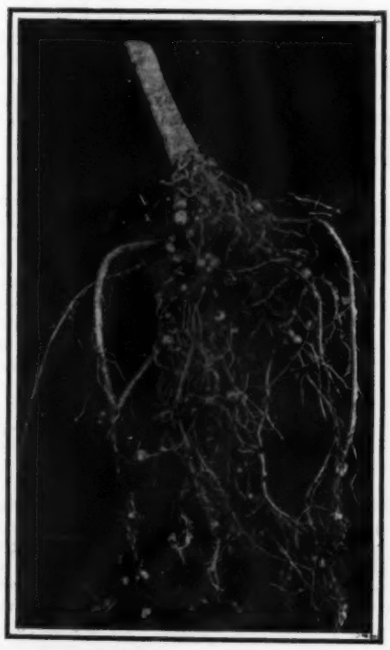
IN 1877 Prof. Todd, from a graphic investigation of the still outstanding differences between the computed and the observed places of Uranus, after allowing for the action of Neptune, considered that an unknown planet existed lying beyond the latter. He accordingly made search for it with the great Washington telescope, but was unable to find any such body.

Prof. George Forbes has recently revived some earlier calculations indicating the possible existence of a trans-Neptunian planet, and he considers his former speculations have been greatly strengthened by additional facts unknown to him at the earlier period. He thinks that three comets which appeared in 1843, 1880, and 1882 are in reality parts of the comet of 1556 (sometimes known as the comet of Charles V, from its appearing at the time of that monarch's abdication), which has been broken up by the action of an unknown planet lying beyond Neptune. It is well known that the planets Jupiter, Saturn, Uranus, and Neptune are associated in an especial way with particular comets. For instance, the short period comets known by the name of Faye, De Vico, Brorsen, and Encke, which revolve in elliptic orbits having periods of revolution round the sun of from three to eight years, all of them approach at certain parts of their orbits very close to that of the planet Jupiter. Similarly, Halley's comet, whose return is hourly expected, Olbers's comet of 1812, and Pons's comet of 1812, rediscovered by Mr. Brooks in 1883, approach very near to the orbit of Neptune, their greatest distance from the sun (aphelion) lying a little beyond that planet. Tempel's comet and two others are similarly associated with Uranus. These various comets are frequently called the "planets' families" of comets, and they are supposed to have become so in the following way: A comet coming from outer space into our system toward the sun will have its rectilinear motion converted into a parabolic one, will approach the sun with increasing speed till it arrives at its nearest point (perihelion), and then once more recede from it. If, however, it comes near a planet in its motion its speed will be either accelerated or retarded. If accelerated, the parabola becomes a hyperbola and the comet moves off even more quickly from the sun after perihelion. If, however, it is retarded, the parabolic orbit is changed into an ellipse, which is a closed curve, and the comet will now become a permanent member of the system, moving in a path which will pass through the region where the disturbance originally took place. The successive diminutions of velocity may greatly transform the comet's original orbit. The converse instance of an increase of speed seems to have happened in the case of Lexell's comet of 1770, which, it is thought, has had its elliptic orbit made hyperbolic by the action of Jupiter.

Another theory as to the origin of comet families, suggested by the late Mr. Proctor, supposes these bodies to have been thrown off by some kind of eruptions from the sun and planets—e. g., that the comets of Jupiter's family once formed part of his mass, but were rejected with sufficient speed to set them free in space, though still under the sun's influence. On either theory we see that there must be some connection between the comets and the planets to whose families they respectively belong.

As we have seen above, Prof. Forbes considers the three comets 1843, 1880, and 1882 were originally parts of one and the same body. Their aphelion (greatest) distance from the sun is about the same, 88 times the earth's distance, and the common position of all three is in longitude 101 deg. and latitude 35 deg. S. Seven comets have been found having their greatest distance at about 100 times the earth's distance from the sun, and four of these have their orbits lying nearly in a plane passing through the sun. He, therefore, suggests that this is in all probability the true plane of the orbit of an unknown planet revolving at about that distance from the sun, and consequently having a period of revolution of about 1,000 years, in accordance with Kepler's third law. [The squares of the periodic times of revolution are as the cubes of the mean distances from the sun. Expressed in terms of the earth's distance and period as units $(100)^3 = 1{,}000{,}000 = (1{,}000)^2$.] The dates at which the comets were in aphelion were found to agree fairly well with the dates on which a planet of the periodic time of 1,000 years would be found in or near those four positions; so that the position of the unknown planet may be considered approximately known. Estimates formed by roughly calculating the probable disturbances produced by this planet upon Neptune give such small quantities for the perturbations that no certain evidence of its existence is likely to be obtained by this method at present, unless its mass be enormously greater than that of Neptune, though sooner or later its presence may be thus revealed. Prof. Forbes has estimated that the unknown planet has a mean distance from the sun 105 times that of the earth (more than three times Neptune's distance), that the inclination of the plane of its orbit to the ecliptic is about 52 deg., and that its elliptic orbit has an eccentricity of about 0.16. The fact of the inclination of its path to the ecliptic causing it to be for a large part of its revolution outside the region of the Zodiac, in which the search for new planets has been mainly carried on, may perhaps be the reason that it has hitherto escaped detection. Prof. Forbes concludes that its present longitude in its orbit is about 202 deg. (or 216 deg. with regard to the ecliptic), and its south latitude (distance from the ecliptic) is 34 deg. It is consequently at present only to be looked for in the southern hemisphere or from observatories nearer to the equator than we are.

Prof. W. H. Pickering has just given the place of a supposed trans-Neptunian planet. Its present position is in R. A. 7 h. 47 min., north declination 21 deg.; or in the southeastern part of the constellation Gemini (the Twins). This cannot be the same object as that referred to by Prof. Forbes, but nothing seems to prevent there being two or more bodies moving in planetary orbits outside the orbit of Neptune. It is quite certain that there are many comets revolving in elliptic orbits and thus returning from time to time to perihelion, which recede to far greater distances from the sun. For instance, the famous comet of 1680, which approached so very close to the sun at perihelion that it must have passed through the outer regions of the solar atmosphere, its distance being only about 55,000 miles from the sun's center at that time, recedes in its aphelion to a distance 850 times the earth's distance, or 28 times that of Neptune from the sun. The amount of light and heat received by an equal area of the comet at these respective times



Bean Roots, Showing Nodules in Which Nitrogen-Fixing Bacteria Work.

Peas. Left Inoculated, Giving Greater Root Growth and Vitality. Right Not Inoculated.

INCREASING THE SOIL'S NITROGEN CONTENT.

must accordingly be 19,000 million times more in perihelion than in aphelion, and its velocity also subject to enormous variations. The apparent diameter of the sun would only be 2 sec. when seen from the comet at aphelion, while in perihelion, according to Newton, the comet would be subject to a heat "2,000 times that of red-hot iron," the sun subtending an angular diameter of 85 deg. Owing to the rapidity of its motion, however, the comet would only be subjected to this intense heat for a very short time.

At the other end of our system we have the question of an intra-Mercurial planet. Leverrier, the great French astronomer and one of the discoverers of Neptune, found in 1859 that the motion of Mercury is such that the perihelion (or point of least distance from the sun) changes its position in a manner which cannot be altogether accounted for by the action of the other known planets. It might be explained by the attraction of a planet or a number of small planetoids revolving inside Mercury's orbit and lying nearly in the same plane.

Dr. Lescarbault, a French country physician, announced that he had seen a planet crossing the sun on March 29th, 1859. He was visited by Leverrier who, after severe cross-questioning, apparently satisfied himself that Lescarbault's observation was a genuine one, and calculated an orbit therefrom, the name of Vulcan being given to the supposed planet. However, it has never been certainly seen again, though, if real, it ought several times to have been visible in transit across the sun.

Very careful observations at the times of solar eclipses should certainly reveal the presence of such a body; but so far no one else has yet found the planet, though both Prof. Watson and Mr. Swift, during the eclipse of 1878, thought they saw two bright objects which could not very well be identified with any known stars. Later investigations made by Dr. Peters have shown that Prof. Watson's stars may very possibly have been the stars θ and ζ Cancri; but, so far, Mr. Swift's observations remain unexplained. However, up to the present, no planet lying nearer to the sun than Mercury has been certainly found. Prof. Young considers it "extremely probable that there are a number—perhaps a very great number—of intra-Mercurial asteroids," perhaps each of them not having a diameter exceeding 50 miles or so. So small objects, lying very near to the sun, would be nearly certain to escape detection either in transit or during an eclipse.—Knowledge and Scientific News.

SOME COSMICAL ASPECTS OF RADIOACTIVITY.*

THE DISTRIBUTION OF RADIOACTIVE MATTER.

BY E. RUTHERFORD.

Concluded from Supplement No. 1739, page 283.

DISTRIBUTION OF RADIOACTIVE MATTER IN THE EARTH'S CRUST.

ELSTER and Geitel early observed that many caves and cellars, in which the air had been confined for long intervals of time, were unusually rich in the radium emanation. This was shown by the strong activity observed on negatively charged wires exposed in these confined places. Such a result is to be expected if the radium emanation continuously escapes from the soil, for the amount of it present must increase in such confined spaces. This led them to make an examination of the activity of soils. All were found to be active and many gave off the radium emanation. This effect was especially marked in clayey soils. J. J. Thomson and others showed that the water in many deep wells and springs was impregnated with the radium emanation. The presence of the radium emanation is especially marked in many of the hot springs distributed throughout Europe. Elster and Geitel observed that the sediment from certain hot springs in Italy was unusually rich in radium. Blanc showed that the sediment from certain hot springs gave off freely the thorium emanation. A very great deal of work has been done along these lines in the last few years, and radioactive matter has been found to be very widely distributed, in small quantity, over the earth's crust. The continent of North America has not been so systematically examined as Europe, but Boltwood has shown that a large amount of radium emanation is present in the waters from many deep-seated springs in various localities in the United States. McLennan and Burton have shown that the petroleum from the oil wells in Ontario contains a considerable quantity of radium emanation and also a trace of radium.

There appears to be no reasonable doubt that the earth is the source of the emanation in the atmosphere. This emanation escapes from the soil by the process of diffusion, or is borne to the surface in spring water and is then distributed by the winds. On account of the rapidity of the transformation of the emanations of thorium and actinium compared with that of radium, it is to be expected that the radium emanation will predominate in the atmosphere, and it is a matter of some surprise that the thorium emanation is present in such large amount as is observed in some localities. The emanation of radium must diffuse slowly through the earth, disappearing with time, and it is to be expected, that, apart from deep-seated springs, most of the emanation observed in the air must be derived from a thin skin of the earth's surface not more than a few feet deep.

INTERNAL HEAT OF THE EARTH.

It is thus natural to suppose that there is a very large quantity of radium and other radioactive matter distributed over the surface of the earth. This radioactive matter must be continuously supplying heat to the earth, and it is of great interest to examine the magnitude of this heating effect and its probable bearing on the question of the origin and duration of the earth's internal heat.

In addition to the various properties I have enumerated, radium also gives out heat continuously and uniformly at a rapid rate. A quantity of radium supplies enough heat to melt more than its weight of ice per hour. A pound of radium in the course of a year will emit as much heat as that resulting from the combustion of 100 pounds of good coal. This heat emission of radium and of all the radioactive bodies is in reality a secondary property, for it is a consequence of the bombardment of the active matter by the α particles expelled from its own mass. The β and γ rays produce only a small percentage of the total heating effect. This heating effect of radium must always be proportional to the quantity of radium present and must persist, however sparse may be the distribution of radium throughout the earth's crust. Consequently, there must be a continuous supply of heat to the earth due to the radium and other radioactive matter distributed throughout it. But the heating effect due to a given quantity of radium does not last indefinitely. The radium breaks up into other forms, and after 20,000 years only a small fraction of the radium would remain. This difficulty, however, is not serious, for it is now definitely settled that radium is produced from uranium, and it is found that in old minerals the amount of radium is always proportional to the amount of uranium.

Now uranium is transformed extremely slowly in comparison with radium, and probably a period of at least one thousand million years would be required before the uranium was half transformed. Consequently, the supply of radium from the breaking up of uranium will keep up the amount of radium in the earth to a nearly constant value for periods measured by hundreds of millions of years.

We shall now consider briefly the ordinarily accepted theory of the origin of the earth's internal heat and of the age of the earth. It is known that the temperature of the earth steadily rises as we proceed from the surface inward, and on an average rises 1 deg. F. for every fifty feet of descent. From the evidence of volcanic action, it is concluded that the interior of the earth is at a high temperature.

Lord Kelvin attacked this question of the age of the earth by supposing that the earth was originally at a temperature of molten rock and has since that time gradually been cooling by the radiation of heat through the surface into space. According to this theory, the temperature gradient near the surface of the earth has been gradually decreasing. Knowing the temperature gradient to-day, and the average conductivity and specific heat of the materials of the earth, it is possible by the aid of Fourier's celebrated analysis to deduce the interval that has elapsed since the earth was a molten mass. Some of the values of the quantities necessary in the calculation are uncertain within limits, but Lord Kelvin concluded that certainly not more than 100 million years can have elapsed since the surface of the earth was at a temperature capable of supporting animal and vegetable life. In later papers this estimate has been still further reduced, and the age of the earth is put as low as forty million years. I cannot here enter into the intermittent controversy that has raged for nearly half a century between Lord Kelvin on the one hand and the geologists and biologists on the other. The latter initially required a much longer period for the progress of geologic and biologic evolution than that allowed by Kelvin, but there appears to be a general consensus of opinion among geologists and biologists to-day, that a period of 100 million years allows sufficient time for the process of evolution.

On the assumptions made by Lord Kelvin, there is no doubt of the general accuracy of the deductions. Let us, however, examine these fundamental premises. The earth is assumed to be a cooling body isolated in space, and it is assumed that there has been no supply of heat to the earth since the cooling began; for Kelvin has conclusively shown that the heat supplied from ordinary chemical processes, that may be supposed to occur in the earth, is not sufficient to influence materially the conclusion as to the age of the earth's heat. But the discovery of the presence in the earth of active matter like radium which emits heat at a rapid rate, at once suggests the possibility that the earth is not a simple cooling body, but one in which heat is being steadily generated. In 1902, I made some calculations to determine how much radium (or other radioactive matter expressed in terms of radium) would be required to be uniformly distributed throughout the earth in order to maintain the present observed temperature gradient. In such a case, the heat supplied by the radium must exactly compensate for that lost from the earth by conduction to its surface and radiation into space. The calculations are simple, and show that a uniform distribution of radium amounting to only 1.7×10^{-12} gramme of radium per cubic centimeter would suffice. From the data then available, I calculated that the amount of radium present in the earth was probably of the right order of magnitude to produce such a result.

Recently, the Hon. R. J. Strutt has made a number of systematic observations to determine the distribution of radium in the typical rocks of the earth's crust, and has obtained results of remarkable interest. Strutt collected a number of typical rocks, both igneous and sedimentary, obtained from widely different localities, and determined the amount of radium contained in them. The rocks were first of all obtained in solution and placed aside in closed vessels. After a definite time the emanation, generated by the radium contained in them, was boiled out, and passed into a suitable electroscope. The amount of radium in the solution was then determined by comparison with the effect in the electroscope due to the emanation from a standard solution containing a known quantity of radium bromide.

The following table shows the observed amount of radium in grammes per cubic centimeter of rock for samples of igneous rocks.

I mentioned before that about 1.7×10^{-12} gramme of radium per cubic centimeter distributed uniformly throughout the volume of the earth, would keep up the earth's internal heat. An examination of the table, however, shows that the surface rocks contain far more radium than this. As we should expect, the radium content varies considerably, but the poorest rock of all, Greenland basalt, contains more than ten times this estimate, while the average rock contains fifty or sixty times as much. An examination of the sedimentary rocks shows an average amount of radium somewhat smaller than that of the igneous rocks, but still of the same order of magnitude. Strutt considers that 5×10^{-12} gramme of radium per cubic centimeter is a fair average for the surface rocks of the earth—a quantity thirty times greater than that required to maintain the present temperature gradient. This is a surprising result, for although of necessity only a small number of rocks have been examined, yet we must consider that the results obtained by Strutt probably give the right order of magnitude for the distribution of radium in the earth's crust. It will be observed that very few rocks from the American continent have a place in the list. This

* Journal of the Royal Astronomical Society of Canada.

emission will no doubt be soon rectified by other observers. It is of interest to note that Eve and MacIntosh of McGill University have recently examined the amount of radium in the typical rocks in the neighborhood of Montreal, and have obtained an average value in substantial agreement with Strutt. By

No.	Name of rock	Locality	Density	Radium per gram in grams	Radium per c.c., in grams
1	Granite	Rhodesia	2·63	$9·56 \times 10^{-12}$	$25·2 \times 10^{-12}$
2	"	Lamorna Quarry, Cornwall	2·62	9·35 "	24·5 "
3	Zircon syenite	Brevig, Norway	2·74	9·30 "	25·5 "
4	Granite	Rosemorran, Cornwall (?)	2·62	8·43 "	22·1 "
5	"	Cape of Good Hope	2·67	7·15 "	19·1 "
6	"	Knill's Monument, near Carbis Bay, St. Ives, Cornwall	2·61	6·90 "	18·0 "
7	"	Shap Fell, Westmoreland	2·65	6·63 "	17·6 "
8	Eleolite syenite	Laurdal, Norway	2·70	4·88 "	13·2 "
9	Granite	Haytor, Devonshire?	2·61	3·69 "	9·64 "
10	Blue ground	Kimberley	3·06	3·37 "	10·3 "
11	Leucite basanite	Mt. Somma, Vesuvius	2·72	3·33 "	9·07 "
12	Hornblende granite	Assouan, Egypt	2·64	2·45 "	6·47 "
13	Pitchstone	Isle of Eigg	2·41	2·06 "	4·97 "
14	Hornblende diorite	Schriesheim, near Heidelberg	2·89	1·98 "	5·73 "
15	Augite syenite	Laurvig, Norway	2·73	1·86 "	5·07 "
16	Peridotite	Isle of Rum	3·15	1·37 "	4·32 "
17	Olivine basalt	Talisker Bay, Skye	2·89	1·32 "	3·82 "
18	Olivine eucrhite	Isle of Rum	2·97	1·28 "	3·80 "
19	Basalt	Victoria Falls	2·75	1·26 "	3·46 "
20	Hornblende granite	Mt. Sorrel, Leicestershire	2·71	1·25 "	3·38 "
21	Dolerite	Isle of Canna	2·95	1·24 "	3·65 "
22	Greenstone	Carrick Dû, St Ives	2·99	1·14 "	3·41 "
23	Basalt	Giants' Causeway, Antrim	2·80	1·03 "	2·89 "
24	Serpentine	Cadgwith, Lizard	2·60	1·00 "	2·60 "
25	Granite	Isle of Rum	2·61	0·723 "	1·89 "
26	Olivine rock	Isle of Rum	3·22	0·676 "	2·18 "
27	Dunite	L. Scaivig	3·34	0·664 "	2·22 "
28	Basalt	Ovifak, Disco Island, Greenland	3·01	0·613 "	1·84 "

calculations based on the intensity of the penetrating or γ radiation at the earth's surface, Eve has deduced a value of the amount of radioactive matter in the earth's crust even greater than the average value found by Strutt. Not only, therefore, is the apparent amount of radium in the earth's crust sufficient to account for the maintenance of the earth's internal heat, but if uniformly distributed throughout its mass, there is far more than is required. The latter assumption would lead to the conclusion that the earth is growing hotter instead of colder—an explanation not likely to be regarded with favor. In order to get round this difficulty, Strutt suggests that the distribution of radioactive matter is not uniform throughout the earth, but is confined to a thin surface shell of the earth. Assuming the distribution of radium found by experiment to be uniform throughout this shell, it can readily be shown that its thickness is about 45 miles. In support of this explanation he cites the results of Milne, the seismologist, who concludes from an examination of the velocity of propagation of earth tremors through the earth, that there is a fairly abrupt transition of the material of the earth's crust at a depth of 30 miles. Below this depth the material appears to be uniform, and transmits earth tremors at quite a different rate from the surface rocks.

On the assumption that radium is confined to a shell 45 miles deep, it is easy to calculate the temperature of the earth as we proceed downward. The results are shown in Fig. 3.

The temperature should rise to about 1,500 deg. C. at a depth of 45 miles. The temperature of the interior mass of the earth below this depth must be uniform and equal to 1,500 deg. C.

It is difficult at present to advance satisfactory reasons why this superficial distribution of radium should occur. Temperature can have little if any effect, for Bronson has conclusively shown that the radiating power of radium is not altered by exposure to a temperature of 1,600 deg. C.

There is another interesting point raised by Strutt in regard to the internal temperature of the moon. The latter is supposed to have been initially separated from the earth's surface, and should thus contain the same average amount of radium as that found in the earth's crust. If this be the case, it can readily be deduced that the temperature gradient in the moon should be about eight times greater than in our earth. Taking into consideration that the force of gravity is small at the moon's surface, the conditions would appear to be very favorable for volcanic action in the moon. This is contrary to the general opinion that the lunar craters are extinct, but as Strutt points out, this view rests chiefly on an *a priori* conviction that the moon has no internal heat. Prof. W. H. Pickering has pointed out that close students of the moon believe that changes are still occurring there.

I hope that I have made clear to you how the study of radioactivity has profoundly altered our views of the earth's internal heat. The conclusions advanced are by no means completely proved, but sufficient has been done to cast grave doubt on the validity of the older theories of the origin and variation of the earth's internal heat.

AGE OF RADIOACTIVE MINERALS.

This new point of view of regarding the supply of the earth's heat does not throw any definite light on the problem of the age of the earth. This want, however, is supplied by taking into account still another very remarkable property of radium. In addition to its property of radiating and of emitting an emanation, radium also steadily produces from itself another stable element, helium. This property of radium was first shown by Ramsay and Soddy, and has been amply confirmed by other investigators. The weight of evidence at the present time points to the conclusion that the α particle, expelled from radium and its products, is in reality a helium atom, which at the moment of its expulsion carries a positive charge of electricity. Whatever may be the position of helium in the general scheme of radioactive transformations, there is no doubt that radium produces helium at a slow but constant rate. The rate of production of helium has not yet been measured with accuracy, but it is probable that one gramme of radium will produce per year about one-tenth of a cubic centimeter of helium at standard pressure and temperature.

This rare gas helium, which next to hydrogen has the lightest atom known to chemists, has had an unusually dramatic history. It was first discovered in the sun by means of the spectroscope by Lockyer in 1868, and hence its name. It was not found in the earth until 1895, when Ramsay showed that the gases liberated from the mineral cleveite showed the spectrum previously attributed to helium in the sun. Now it is a very interesting fact that helium is only found in quantity in the radioactive minerals. The presence of helium in these minerals was at first considered very remarkable, but is at once explained if the helium is produced in the mineral by the radium or other radioactive matter contained in it. Consider, for example, a very dense radioactive mineral from which the helium continuously generated by the radium cannot escape. The amount of helium in the mineral will steadily increase with time, and the

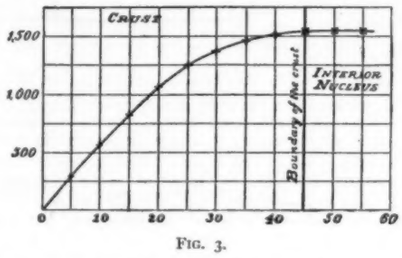


FIG. 3.

total amount present should be proportional to the age of the mineral and the amount of radium contained in it. I have here some crystals of a new mineral, thorianite, found a few years ago in Ceylon, which contains about 12 per cent of uranium and about 70 per cent of thorium. This mineral on heating evolves a remarkably large quantity of helium—more than 10 cubic centimeters per gramme of the mineral. Now it is almost certain that the helium stored up in this mineral has been produced by the breaking up of the radium contained in it since the formation of the mineral. Assuming the rate of production of helium by radium already mentioned, it can be calculated with some confidence that the mineral thorianite is at least 500 million years old, i. e., this interval of time must have elapsed since the formation of the mineral in the earth's crust. This is a minimum estimate, for probably some of the helium has in the course of ages escaped from the mineral. A similar result is obtained from consideration of other primary radioactive minerals. Most of them are apparently about 500 to 1,000 million years old.

When the constants involved in these calculations are accurately determined, I feel great confidence that this method will prove of the utmost value in determining with accuracy the age of the radioactive minerals and indirectly of the geologic strata in which they are found.

CONCLUSION.

I have so far confined my attention to the earth and her satellite the moon. Is there any evidence of the presence of radium or other radioactive matter in the sun or in the stars? We may say at once that no definite evidence has yet been observed. From the similarity of the chemical constitution of the sun with our earth, we should expect the sun to contain radioactive matter also. The large amount of helium observed in the sun directly supports such a conclusion. Strutt found that stony meteors contained about as much radium as the surface rocks of the earth, indicating that these visitors from other systems also have their share of radium.

There is no obvious reason for supposing that the sun, at any rate during the initial stages of its condensation, contained much more radioactive matter than the earth. According to the condensation hypothesis of Kelvin and Helmholtz, the heat of the sun is derived from the gradual concentration of its material due to gravitation. On this hypothesis, Kelvin considers it improbable that the sun will continue to shine at its present brilliancy for a period of more than 12 million years, and probably much less. There is one possibility, however, which may greatly extend the estimate of the duration of the sun's heat. At the enormous temperature of the sun, it is possible that ordinary matter may become radioactive, i. e., it may break up into simpler forms, with the evolution of a great quantity of heat. If ordinary matter, in undergoing such change, emitted as much heat as radium in its transformation, this new source of heat would allow the sun to shine for a much longer period than the older theory allows. This is only a speculation, but one that must be taken seriously into consideration in coming to a decision of the probable duration of the sun's heat, and consequently of the time for habitation of our globe.

SOME ROMAN BUILDING MATERIALS.

By NICHOLAS KNIGHT.

LONG ages after the far-famed "seven hills" were lifted above the sea by volcanic action, and all the region round about the "eternal city" had become dry land, there came an era of large fresh-water lakes and a river Tiber many times larger than the present stream. These fresh waters were heavily impregnated with carbonic acid, and they dissolved quantities of the limestone with which they freely came in contact. This limestone was deposited in various places and is known as *travertine*. The extensive deposits near Tivoli, about twenty miles from the city, at the foot of the Sabine hills, have furnished a large amount of building material. The quarries there located have been utilized from the time of the emperors to the present. The Colosseum is built of travertine, and it has defied the vicissitudes of time during sixty generations of men. This serves to indicate the wonderful staying qualities of the material. The beautiful red sandstone in the British houses of Parliament erected in about 1830 is rapidly becoming disintegrated, although in a comparison of this kind it must be remembered that the English climate like the American makes more strenuous demands upon a building than the milder, dryer climate of sunny Italy.

The durability of travertine is still recognized and the new palace of justice, which has been several years in building and which when completed will rank as one of the finest modern structures in all Italy, is being constructed of this material.

We have never noticed an analysis of the rock although many have doubtless been published. A specimen analyzed as follows:

$CaCO_3$	90.50
$MgCO_3$	3.65
SiO_2	3.36
Fe_2O_3	0.76
Al_2O_3	2.06
	100.33

The chemical analysis scarcely furnishes a clue to its enduring qualities, which are rather to be sought in its physical characters. It looks durable. It is vesicular, the vesicles lined with drusy calcite and light yellowish gray in color. It contains some long thread-like cavities, apparently of organic origin. It is crystalline and an old surface contains no grains that are detachable by the finger. The specific gravity is apparently higher than that of ordinary limestone.

Rome was fortunate in the variety of its native construction materials and in its easy accessibility to the marble quarries of Asia, Africa, Greece, and the islands of the Mediterranean. Augustus proudly boasted that he found Rome brick and left it marble. What a pity that so many of the finest buildings and works of art, some of the world's greatest masterpieces, were ruthlessly burned for quicklime! Fragments of these ancient marbles recently picked up on the Forum (when the custodians were not looking) gave the following results when analyzed:

$CaCO_3$	90.37
$MgCO_3$	2.47
SiO_2	3.17
Fe_2O_3	2.46
Al_2O_3	1.37
	99.84

There is quite a striking resemblance in the composition of the two materials which one would scarcely expect.—School Science and Mathematics.

Mothproof paper, for the preservation of furs, clothes, etc., may be made by saturating Manila paper with a fluid of the following composition, then pressing it and drying it by passing over heated rollers. The mixture consists of 70 parts coal tar oil, 5 parts crude carbolic acid, containing at least 50 per cent of phenol, 20 parts of thin coal tar, heated to 158 deg. F., and 5 parts of refined petroleum.

THE FLIGHT OF BIRDS.—I.*

THE MECHANICS OF A BIRD'S WAY IN THE AIR.

BY F. W. LANCHESTER.

IN the flight of birds it is customary to recognize three methods or modes of flight, namely: (1) The gliding mode (or, *vol plané* of the French), in which the bird, poised on rigid pinions, gradually descends along an inclined path; (2) the soaring mode (*vol à voile*), which in appearance resembles the gliding mode, except that the bird does not descend, but may even increase its altitude; (3) the active mode (*vol ramé*), characterized by the flapping of the wings.

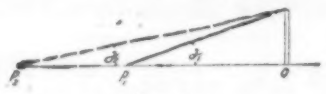


FIG. 1.

This classification, like many others that it is convenient to adopt, is admittedly of a rough-and-ready kind; in fact, the gliding mode is the essential mode of flight, and both soaring and active flight involve the gliding mode with certain additions. Thus we must really consider mode (1) as the essential mode of flight, and (2) and (3) as variations to be studied subsequently.

In simple gliding the problem of flight is presented in its most elementary form. Taking the primary object of flight to be locomotion, gliding flight permits of a bird passing from one point to another without muscular exertion, its weight wholly sustained by the aerodynamic reaction on its outspread wings, and the energy necessary to overcome its line-of-flight resistance supplied by the descent of its mass under the influence of gravity.

It is evident—bearing in mind that the object of flight is locomotion—that the bird which is of the most efficient design will descend at the smallest gliding angle, the gliding angle being in fact an inverse

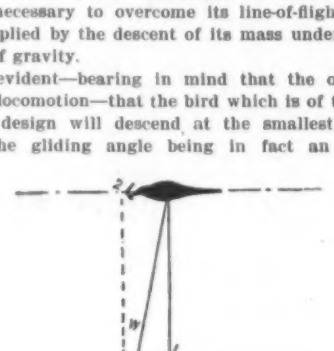


FIG. 2.

measure of efficiency, for, for a given initial altitude, the bird whose gliding angle is least will be capable of the longest trajectory before coming to earth.

The manner of propulsion in gliding flight is best demonstrated by the resolution of the force of gravity along the line of flight and at right angles thereto—Fig. 2. The former may be regarded as the force of propulsion, and the latter as the load sustained. So long as the gliding angle is a small angle, which, in effect, it usually is, the component 1 normal to the flight path may be taken as sensibly equal to the weight *W*, so that a force of propulsion *F* may be substituted for the line-of-flight component of gravity 2 without essentially affecting the conditions—Fig. 3. It thus becomes apparent that the gliding angle represents the gradient that a bird or flying machine

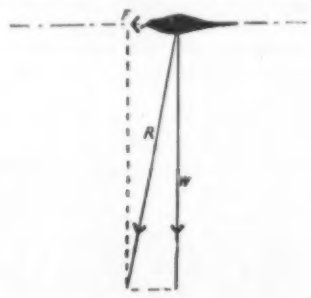
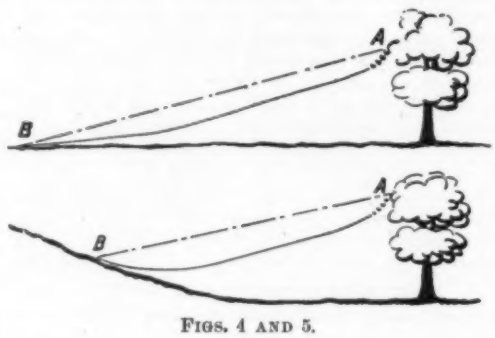


FIG. 3.

has continuously to climb in order to sustain itself in horizontal flight; and thus if in any particular case we know the gliding angle, we can at once calculate the energy necessary to flight.

Let us take, for example, the hypothetical case of a pelican of 14 pounds weight, which we will assume has a gliding angle of 8 deg., or 1.7, then the necessary force of propulsion will be 2 pounds, and if its velocity of flight be 60 feet per second, the power necessary to flight will be 120 foot-pounds per second, or at the rate of $\frac{550}{120} \times 14 = 64$ pounds sustained per horse-power. In reality the expenditure will be greater, owing to the inefficiency of the means of propulsion. In the case of a flying machine driven by a screw propeller this loss of power is at best in the neighborhood of one-third of the total; that is, the highest efficiency obtainable is somewhere about 67 per cent. On the efficiency of wing propulsion very little is known; some suggestions are given later in the present paper.

Considering the importance of ascertaining the gliding angle, namely, the minimum gliding angle of which any particular species is capable, very little reliable work has been done; indeed, the measurement, simple as it is in the case of models, is one which in the case of living things it is not easy to make. The most reliable determination is probably that of Bretonniere, who, from observations on the flight of storks made over a distance of about one kilometer, gave the gliding angle as approximately 10 deg. or 1:5.7, the velocity being about 20 meters per second.



FIGS. 4 AND 5.

Measurements of the gliding angle made over short distances are, generally speaking, not reliable. There is considerable analogy between a gliding bird and a cyclist free-wheeling or "coasting"; in both cases the energy required for propulsion is supplied by gravity, and in both cases this fact may be temporarily obscured by undulations in the road or flight path, as the case may be, the kinetic energy constituting a reservoir that is drawn upon and replenished as occasion requires. Thus a gliding bird may often be seen to rise to clear an obstacle, just as a cyclist free-wheeling may be carried over a culvert or hillock by his impetus. Moreover, just as the change in the velocity of the cyclist may not be noticeable, so also it is easy for the change in the velocity of a bird to escape observation, and so an inexperienced observer will be led into error.

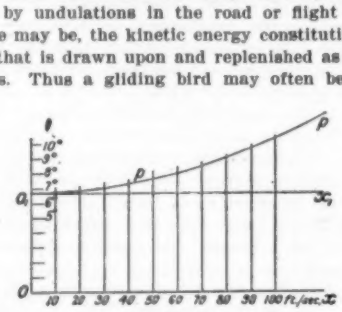


FIG. 6.

Let us consider the familiar case of a rook or crow alighting in a field; the bird may often be observed to leave a tree (Fig. 4) and after a plunge accompanied by a few strokes of the wing at *A*, it will glide gently down and alight at *B*. The terminal portion of this glide will, perhaps, be at an angle of 2 deg. or 3 deg., or even less, but the velocity is gradually diminishing, and so the angle observed is not the true gliding angle, any more than would be the case if as illustrated in Fig. 5, in which the bird may be actually ascending when about to alight. In both these cases the gliding angle at the terminal portion of the flight is fictitious, the energy is mostly being supplied by the emptying of the kinetic reservoir, and not immediately by gravity. In the free-wheeling analogy the corresponding conditions are those of a cyclist who, after the descent of a hill, comes to rest on an approximately level or uphill stretch of road; this simile will perhaps serve to give to the non-technical mind a clear appreciation of the conditions.

It is essential for accuracy that, in the determination of the gliding angle, the velocity shall be the same at the beginning and end of the period observed, or alternately the distance—the length of the flight path under observation—must be so great as to render the difference between the kinetic energy at the beginning and end of the flight an unimportant factor. We may take it that the latter condition was fulfilled in the case of Bretonniere's observations.

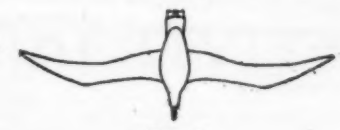


FIG. 7.

In the example illustrated in Figs. 4 and 5, we shall obtain a better approximation to the true gliding angle by joining the points of departure and alighting, *A* and *B*, than by taking any individual portion of the curve, but even this is not accurate, for although the velocity of these two points is equal, being of zero value, the bird commonly flaps its wings for a brief interval, and on alighting it usually has some small residual velocity that it absorbs with its legs. If we could with justice assume that these two disturbing factors neutralize one another, there would still remain the circumstance that flight becomes uneconomical at speeds too far removed from that for which the bird is designed, that is, its ordinary velocity of flight, so that the gliding angle, computed in the manner suggested, would probably be in excess of its true value.

At the present time we know more about the conditions governing the gliding angle and its probable magnitude from pure theory and from model experiment than we do from observations on the flight of birds.

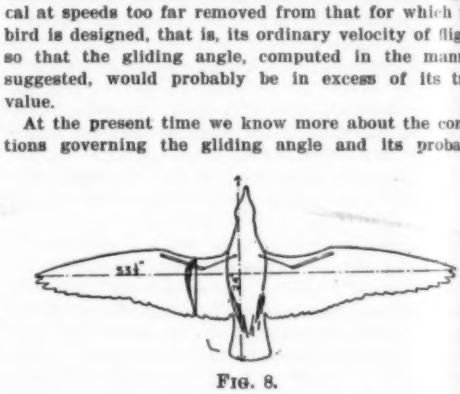


FIG. 8.

Langley believed that the gliding angle could be diminished almost indefinitely by increasing the velocity of flight and by increasing the wing area, but this conclusion rested on a fundamental error in ignoring the tangential drag exerted by the air on the exposed surfaces or "skin friction." Langley explicitly stated his belief that skin friction is negligible. In point of fact the skin friction is not negligible in any sense, and it is a remarkable and important fact that when the influence of this factor is taken into account, the author has shown that the resistance, and therefore the gliding angle, is independent of the velocity.

In the demonstration of this fact it is assumed that the design is varied to suit the velocity, so as to be in every case a design of least resistance; it is also assumed that the resistance in consideration is that essential to flight, to support a stated total load. The resistance offered by the body of the bird—or machine—or body resistance is taken as a separate added resistance which varies according to the well-known V^2 law. The position of affairs is thus shown graphically by Fig. 6, in which the constant flight resistance is given by the ordinate *O O*, and the body resistance by the additional ordinate set off from O, x, as datum, and indicated by the line *p p*, which is a parabola. Abscissæ = velocity and ordinates = resistance.

FIG. 9.

* Read before the Birmingham Natural History and Philosophical Society.

From purely theoretical considerations based on measurements and data of somewhat doubtful accuracy, it would seem that the gliding angle—neglecting body resistance—should have a minimum value round about 4 deg., or 1.14. The theory is, however, admittedly incomplete, and it would appear from experiments made with a large number of carefully constructed models, that the best result to be obtained in practice, after allowing for body resistance, is nearly double this value, and it may be taken as highly improbable that the gliding angle of any existing species

FIG. 10.

of bird is as low as 1:10. Bretonniere's figure is most likely near to the truth not only for the stork but for most other species. Wings of considerable aspect ratio, that is to say, with a span great in proportion to their fore-and-aft dimensions, are at an advantage from an aerodynamic point of view, and other things being equal, give the best results, i. e., the least resist-

FIG. 11.

ance hence we might expect the albatross (Fig. 7) to have a less gliding angle than the herring gull (Fig. 8) or the rook (Fig. 9). It is said that in individual cases the albatross has been found with an aspect ratio as high as 1:12 or even 1:13.*

One remarkable fact in connection with the design of aerial gliders or aerodromes is that the crudest of wing form, i. e., a rectangular flat plane, is nearly as economical—as measured by the gliding angle—as the most carefully constructed pterygoid form. This appears to the author to be analogous to a fact known in the design of the screw propeller; if a propeller is properly proportioned as to diameter and pitch, its efficiency, if made of true helical form—of constant pitch from boss to tip of blade and from edge to edge—is very little short of the best obtainable, the improvement that can be realized by adopting pterygoid form

FIG. 12.

is far less than would be supposed. The above facts are rather paradoxical; the following explanation is given in the author's "Aerial Flight."† Briefly, owing to the plane giving rise to what is known as discontinuous motion (in the air), involving a "dead-water" region (Fig. 10) skin friction on the upper surface is diminished or may become absent or even of negative sign, and thus any loss of power that takes place due to the disconformity of the plane to the system of flow is made good by the reduction in the tangential drag; that is, in effect, by the diminution of the coefficient of skin friction.‡

One of the consequences of the author's theory of least resistance is that the conditions of least resistance are fulfilled when a certain direct proportion exists between the pressure (per unit area) and the square of the velocity, and this relation—the value of the constant connecting these quantities—depends upon the coefficient of skin friction, upon the aspect ratio, and upon the type of aerofoil employed, i. e., whether of plane or of pterygoid form. The full results of the investigation will be found in the author's "Aerial Flight."§

From the present point of view the difference between the plane and the pterygoid form is one of some importance. The pressure for least resistance in the case of the simple plane is less than for the ptery-

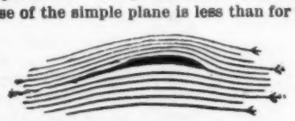


FIG. 13.

goid form, consequently the area required can be reduced if the pterygoid form is adopted. Now, since the supporting members constitute useless load, that is to say, the weight of a bird's wings is not part of the useful cargo, and since the wing weight must increase in some way as a function of the area, we have the probable reason why the aeroplane is not adopted by birds, and that the pterygoid form, having an arched section (Fig. 12) is universally employed, the bird adopts the type that involves the least addition to its weight.

Now, it is a well-known proposition that all difficulties due to structural weight are of little importance when the objects with which we are concerned are of small size, whereas they become of great importance when the objects are large; eventually we know the size of an animal or structure is limited by the available strength of materials. Hence, if the above explanation is correct, we should expect to find in the smallest birds or flying creatures, that the pterygoid form with its stream line system (Figs. 12 and 13) will give place to the true aeroplane with its discontinuous system (Figs. 10 and 11). This is precisely

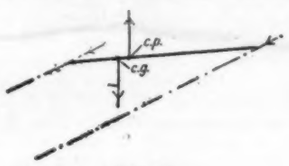


FIG. 14.

what we do find. The wings with which insects, flies, gnats, dragon flies, butterflies, etc., are furnished are approximate aeroplanes, which certainly do not present a concave surface to the pressure region when in use, and which there is every reason to suppose behave as aeroplanes in giving rise to a discontinuous system of flow and in other essential respects. Nature appears to have found it convenient, at the point where it pays to make the change, to vary simultaneously the whole scheme of construction, each scheme belonging to its own independent line of heredity extending back into the remote geological past. It is, however, in all probability the physical principles above discussed that preserve the line of demarkation as to wing form where we find it at present, and which prevent the bird and the flying insect from mutually poaching on each other's preserves, to the ultimate extinction or partial extinction of one or the other. The disappearance of the pterodactyl may be cited as an instance of how completely a whole zoological order may be wiped out of existence by a competing order of more

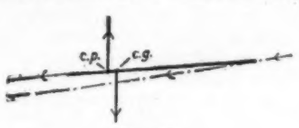


FIG. 15.

efficient design and better mechanical detail, unless the said competitor has points of superiority in some respect or unless there are special reasons or conditions why he should be able to hold his own.

Before entirely quitting the present branch of the subject, it is worthy of note that although butterflies and moths have, generally speaking, wings of the aeroplane type, many of the ornithoptera of the Malay Archipelago show some semblance of the dipping front edge characteristic of pterygoid form; a similar feature is found in a few of the larger moths. At the best, the dipping edge shows itself among moths and

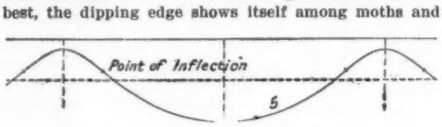


FIG. 16.

butterflies in an extremely rudimentary and undeveloped form, so much so that it is impossible to assert that the appearance of the feature is of any real significance.

We have so far confined ourselves to the discussion of some of the more important considerations presented by the economic aspect of the subject, and no attempt has been made to explain why a rigid model or aerodone, in its simplest form consisting merely of a flat rectangular ballasted plane, is possessed of such marvelous stability, why in fact it glides smoothly to earth with a perfectly self-regulated velocity like a living bird. We will now turn our attention to this aspect of gliding flight; it is evidently possible that the gliding bird also owes its stability to ordinary dynamic laws coupled with its own capacity for assuming a rigid attitude, and not—as has been commonly supposed—to a continual and watchful exercise of skill or intelligence.

The author has, in his "Aerial Flight,"* submitted the theory of the longitudinal stability of a simple aerodone to a mathematical analysis, in which an equation is reached defining the character and form of the flight path; the general principles, however, are better grasped by a less rigid qualitative treatment as in the opening chapter of the second volume of the work in question. For the present purpose the ballasted aeroplane may be taken for the purpose of demonstration; the more highly developed aerodone involves in reality no new principles.

When a plane is moved through the air inclined by a small angle to its direction of motion, the center of pressure is situated at a point very much in advance of the center of figure; the greater the angle the nearer does the center of pressure approach to

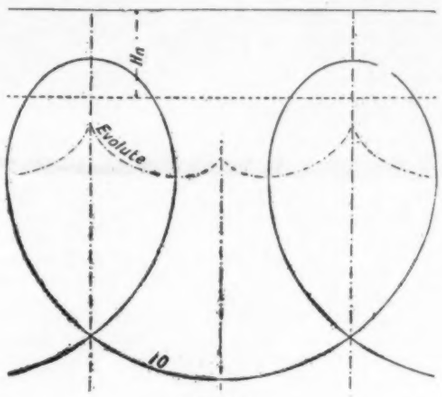


FIG. 17.

the center of figure, and the less the angle, up to a certain point at least, the farther the two are separated. The result of this is that when an aeroplane is gliding free from constraint, and if it be so ballasted as to bring its center of gravity into a position which corresponds to that of the center of pressure at a stated angle, say β, then so long as the aeroplane is making this particular angle β to its line of flight, the action and reaction are in the same straight line, and there is no couple tending to cause the angle to increase or diminish. If, owing to any disturbance of the flight, the angle at any time should

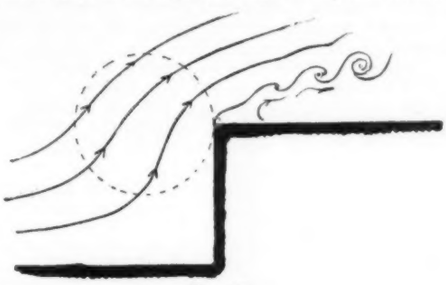


FIG. 18.

become too great, the center of pressure moves aft and a couple arises tending to correct the error—Fig. 14; if, on the contrary, the angle becomes too small, the center of pressure moves forward and again the couple tends to correct the departure—Fig. 15. Thus the angle made by the plane to its line of flight is one of equilibrium. The same obviously applies to an aerodone of bird-like form, only here the displacement of the center of pressure of the aerofoil is comparatively trivial owing to its being of pterygoid section, but the tail plane insures the attitude of the aerodone being stable.

So far we have only reached the result specifically stated; it has not been shown how the velocity is self-regulating. It is evident that for the stated angle there is some particular velocity—termed by the author the natural velocity—at which the aerodynamic reaction experienced by the aerodone will be just sufficient to sustain the weight, and that so long as this velocity is maintained there will be no tend-

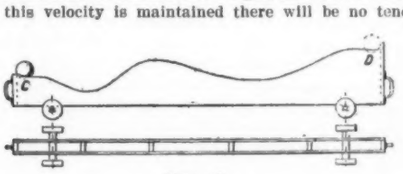


FIG. 19.

ency of the aerodone to alter its (vertical) course. If, now, we suppose that the aerodone be launched at its natural velocity in a direction inclined downward at just such an angle as will provide a gravity component sufficient to overcome the resistance to flight, its condition will be one of equilibrium—it will continue to glide uniformly *ad infinitum;* it remains for us to determine whether or not the said equilibrium is stable or otherwise. Let us suppose some slight disturbance to take place either as to velocity or angle; let us suppose, for example, that the flight

* "Aerial Flight," vol. I, Aerodynamics, Chapter VII.

† Vol. I, Aerodynamics, §§ 182 *et seq.*

‡ Fig. 10 gives diagrammatically the form of flow, known to hydrodynamic theory as a discontinuous system. Fig. 11 shows how, according to the experiments of Prandtl, the surface of discontinuity breaks up into vortices.

§ Vol. I, Aerodynamics, §§ 185 *et seq.*

* Vol. II, Chapter II.

path be too steep. Then the gravity component will exceed the resistance and the velocity will be increased; this will result in an increased pressure reaction in accordance with the V^2 law; this excess of pressure reaction will result in the flight path being diverted upward, that is, the path inclination will be lessened, and so the gravity component will diminish, and after a time the velocity will become reduced. If we follow the matter further we see that the flight path continuing its direction of diminished inclination will result in the pressure reaction being insufficient, when the unsupported weight will tend again to increase the flight path angle, and the whole cycle of changes will be repeated. It is thus evident that the conditions are those of stable equilibrium, any disturbance resulting in a restoring change, and the result being an oscillation, the flight path becoming of wave-like form.

This is precisely the result arrived at by the mathematical analysis, by which it is shown that the undulations are of approximately trochoidal form, the orbit of the trochoid-like path being for small amplitudes of elliptical form, the major axis being vertical, and $\sqrt{2}$ times the minor or horizontal axis (Fig. 16). In Fig. 17 other examples of the curve are given, but it is with the inflected series, and, in particular, with the approximate trochoid, we are mostly concerned in real flight. The curves (Fig. 17) in which the bird or aerodone "loops the loop" are called tumbler curves, from their resemblance to the evolutions of a tumbler pigeon. It is a rather interesting fact that the particular case defining the separation of the tumbler and inflected series is a semicircle.

In addition to demonstrating the form of the curves as above on an hypothesis that leaves certain factors out of account, the author has followed the matter up by dealing with these factors in a subsequent investigation. It is shown in brief that the influence of resistance to flight is to damp out the oscillations, so that any disturbance of the flight of an aerodone will tend to die away, and the flight path settle down to the steady state. It is further shown that the influence of moment of inertia about a transverse axis has the opposite effect, and, in order that the flight path should be stable the oscillation must be made to damp out, and, in order that this should take place, a certain equation must be complied with, termed the equation of stability.

In the author's work this equation of stability is confirmed by model experiment, and it is then applied to (*a*) the common swift and (*b*) the wandering albatross, and in both cases the evidence is strongly in favor of the view that for birds in simple gliding flight the stability is automatic.

This application of the author's equation to actual birds is for several necessary reasons no more than a rough approximation, still the results are such as to leave very little doubt in the author's mind as to the fact.

We have now concluded our survey of the subject of gliding flight, and may proceed to consider the various means utilized by birds for propulsion. We will first deal with the soaring mode.

It is a well-established fact that many birds habitually remain in the air for indefinite periods of time without the visible expenditure of muscular energy. We know enough about the economics of flight to understand that no expenditure of muscular energy that is not visible and obvious can account for the performance of the work necessary to flight; consequently we are led to infer that the supply of energy must be sought elsewhere. Birds observed under the above conditions are said to soar.

Soaring flight is of two main kinds: (1) The bird is sustained on an upcurrent or by the upward component of a wind that is not horizontal in direction; (2) the bird utilizes the turbulence energy of the wind or internal work of the wind as it has been termed by Langley.

The theory of the first of these kinds of soaring is of the most elementary simplicity. In the case of a direct upcurrent it is only necessary for the upward velocity of the wind to be equal to, or in excess of, the velocity of gliding descent for the bird to be able to glide continuously without loss, or even with a definite gain of altitude. If the upcurrent exists as the vertical component of a wind possessed of considerable horizontal motion the conditions are perhaps a trifle more complicated. Thus birds may be frequently observed soaring above the flank of a mountain where the wind, ordinarily horizontal, has a vertical component imparted to it. In this case not only is it necessary that the upward velocity shall be in excess of the velocity of gliding descent, but it is also necessary that the inclination of the wind direction shall be as great or greater than the gliding angle, for otherwise the bird, although not losing altitude, is unable to stem the air current, and sooner or later will be carried out of the favorable region to some point where the upcurrent no longer exists. In practice the slope of the mountain requires to be considerably steeper than the gliding angle, for soaring to be of service the bird must be able to come and go and wheel at will; beyond this the wind current will not, save in exceptional cases, be as steep as the gradient by which it is deflected, so that where birds are commonly seen to soar, the slope is usually precipitous.

One of the most common situations where upcurrent soaring may be witnessed is in the vicinity of the perpendicular cliffs that abound along our coasts; when a sea breeze is blowing, the upcurrent is sufficient, even at some quite considerable distance in front of the cliff, to sustain a soaring bird. The form of flow in such a situation is represented approximately in Fig. 18, the dotted circle being intended roughly to define the region in which the air current will best serve the purpose of sustentation.

The second variety of soaring, in which the bird derives its energy from the irregularity of the wind, is more difficult to comprehend, for it involves dynamical considerations of a somewhat complex kind. A bird is not able to utilize the main horizontal current of the wind for its support like a string kite, because it has not, like the latter, an anchorage that will prevent it partaking of the motion of the wind itself. If the motion of the wind were horizontal and uniform, the position of a bird with regard to flight would be just the same as in still air; in fact, when there is no wind in the ordinary sense we may regard the motion of the air, carried round with the earth, as a colossal wind of a perfectly uniform character, and the identity of the conditions of still air and uniform horizontal wind, so far as a bird is concerned, becomes at once apparent.

It has been shown by meteorological observation, and, indeed, it is otherwise a well-known and obvious fact, that wind is not a uniform motion of the air, but one that involves many other kinds of disturbance; the motion is said to be turbulent, and the turbulence is relatively greater the higher the velocity of translation. In some cases the turbulence is due to forms of motion that persist and move from one part of the fluid to another, such as vortices; in other cases the irregularity is due to the immediate influence of an obstacle, but in whatever form the turbulence is present the bird is able to play off the motion of one part of the air on another part, and if it conduct its operations on the principles of endeavoring to check those parts of the wind that are moving too rapidly, and to accelerate those that are moving too slowly, there will result an unlocking of the energy of turbulence, which will become available for the purposes of flight.

The author has shown, on a simplified hypothesis, that so long as the velocity of mean square of the turbulence in the air dealt with by the bird is sufficient proportionally to the square of the velocity of flight, the supply of energy will be sufficient for dynamic soaring; it further appears, at least in a conventional case chosen for examination, that the bird is only able to utilize half of the calculated energy—that is, the efficiency of dynamic soaring cannot exceed 50 per cent, but whether this limitation is of general application is not known, neither is the precise reason for its existence altogether clear.*

The most effective method of demonstrating the principles of dynamic soaring is by means of the "switchback" model (Fig. 19). We may regard the path of a bird in the air as defining an imaginary track on which the bird is supposed to slide, the fluid resistance to its motion being analogous to the frictional resistance that would exist in the case of the track. Now the bird finds pulsations in the air through which it travels, and it fits to these pulsations undulations in its flight path by which the energy required for flight is trapped. In the switchback model the conditions require, for obvious reasons, to be reversed; the undulations in the track are predetermined, and pulsations are applied by hand to fit in or synchronize with the motions of a ball which is employed to represent the bird in flight. The energy trapped by the dynamic action is evidenced by the raising of the ball from a lower to a higher level.

There are several modified forms of dynamic soaring in which the bird adapts its procedure to circumstances; also sometimes soaring may be witnessed of a mixed kind, upcurrents and wind gusts being requisitioned indiscriminately.

We will now pass on to the construction of direct propulsion.

It has already been pointed out that a certain steady force of propulsion, applied in the line of flight, will enable a bird or gliding model to proceed without loss of altitude, and this applied force in terms of the weight sustained must equal or exceed $W \tan \gamma$ where γ is the gliding angle. In mechanical flight such a force is customarily applied by means of one or more screw propellers, but the screw propeller as such is anatomically unknown. The method of direct propulsion universally employed in natural flight is that of wing flapping;* and it is to the theory of wing propulsion that we will now turn our attention.

The general characteristics of active flight are sufficiently well known to render a descriptive introduction to the subject superfluous, but on the more precise nature of wing motion, and on the theory of wing action in the double function of support and propulsion, there is ample room for discussion.

(To be continued.)

"Aerial Flight," vol. ii, §§ 153, *et seq.*

* Some exception may be taken to this statement in the case of the flying fish, which obtains much of its propulsion from its "take off" from the water. It is possible that the same was true of the Pterodactyl *Rhamphorhynchus Phyllurus*, the tail of which was equal in length to the rest of the body, and carried at its extremity a paddle of small area. It seems probable that this creature sped along over the surface of the water, propelling itself by an undulatory motion of the tail, and, when opportunity occurred, snatching at the fish that constituted its prey. This view is suggested by the fact that the paddle is of an area totally insufficient to be of service as an aerial propeller, but it is of quite a suitable size for obtaining the necessary reaction from a denser fluid like water.

SOME COMMON DISINFECTANTS.†

By M. DORSET, M.D

THERE is much popular misconception as to the value and limitations of the various disinfectants which are sold in this country. For this reason the following very brief description of some of the more common of them has been prepared. Full and complete descriptions of these substances may be found in the very excellent treatises of Rosenau,‡ Rideal,§ and others.

FORMALDEHYDE.

Formaldehyde—formic aldehyde—is available on the market as paraform (a sort of condensed formaldehyde, which is sold as a white powder or in the form of pastils) and also in aqueous solution generally known under the name of formalin. The solution is supposed to contain 40 per cent of formaldehyde, though in reality the amount of formaldehyde present rarely exceeds 37 to 38 per cent. Formaldehyde may be used for disinfection in either a liquid or gaseous form.

Liquid Formaldehyde.—Solutions of formaldehyde are best prepared by making a 5 per cent solution of formalin in water. This is applied directly to substances that require disinfection, and in the case of refuse, excreta, and similar substances should be thoroughly mixed with them. A 5 per cent solution of formalin is generally regarded as superior to carbolic acid of the same strength as a general disinfectant.

Gaseous Formaldehyde.—In disinfecting with formaldehyde gas it is essential that the compartments to be disinfected be tightly closed so that a sufficient concentration of the gas may be held in contact with the infected substances a sufficient length of time. The temperature of the air is an important factor in securing efficient action, the formaldehyde being much more energetic in a warm atmosphere than in a cold. The best authorities state that gaseous formaldehyde disinfection should not be attempted if the temperature of the air is below 50 deg. F. The gas is most conveniently secured by liberating it from the concentrated aqueous 40 per cent solution or from the solid paraform. A number of methods for accomplishing this in practice have been devised, the more important of these being as follows:

Production of the Gas from Formalin.—(*a*) Heating under Pressure.—Portable autoclaves specially designed for the purpose are charged with a sufficient amount of formalin, the quantity depending upon the cubic air space to be disinfected. The autoclave is closed and heat is applied until the required pressure within the autoclave is attained. The gas which has been liberated from the solution by the heat is allowed to flow through an outlet tube into the closed chamber which is to be disinfected. The room is then kept closed for from two to twelve hours; the shorter time if only smooth surfaces are to be acted upon; the longer if penetration into fabrics is desired. Ten ounces of formalin should be used for each 1,000 cubic feet of air space.

(*b*) Heating without Pressure.—This method is similar to that just described. Formalin is placed in a specially designed retort and heated with a lamp. The gas is conducted into the compartment to be disinfected by means of a small tube which passes through the keyhole, or other small aperture. Ten ounces of formalin is required for each 1,000 cubic feet of space. The evolution of gas by this method is less rapid than when generated under pressure and a longer time is required for disinfection. The compartment should remain closed for at least six hours, and for twelve hours if penetration into the interior of fabrics, hay, etc., is required.

(*c*) Spraying.—In this method the formalin is sprayed upon the surface of objects which require disinfection or upon sheets which are hung up in the compartment containing the infected materials. The

† Farmer's Bulletin 345, issued by the United States Department of Agriculture.

‡ "Disinfection and Disinfectants." Philadelphia, 1902.

§ "Disinfection and the Preservation of Food." New York, 1903.

gas is liberated by simple evaporation, this liberation being favored by the wide surface which is exposed. The gas is liberated much more slowly by this method than by either of those already described, and the diffusion is also relatively much slower. For these reasons the compartment to be disinfected should not be very large, and should remain closed for at least twenty-four hours. Not less than 10 ounces of formalin should be used for each 1,000 cubic feet of space.

(*d*) Liberation of the Gas by Chemical Means.—Several methods of liberating formaldehyde from formalin solutions without the use of artificial heat have been proposed in recent years. The most important of these is known as the "permanganate method." Formalin is poured upon crystallized or powdered potassium permanganate. A violent chemical reaction takes place immediately, heat is generated, and a rapid liberation of formaldehyde gas takes place. As will be understood, the heat is caused by the reaction between the formaldehyde in solution and the permanganate, a large portion of the formaldehyde being consumed by the reaction. The amount of gas evolved depends in great measure upon the relative weights of permanganate and formalin employed. Experiments have shown that when the formalin and permanganate are mixed in the proportion of 6 parts of formalin to 5 parts of chemically pure permanganate, by weight, 50 per cent of the formaldehyde employed is liberated in the form of gas. If 10 ounces of formalin are required for disinfection of 1,000 cubic feet of space by the first three methods described, twice that amount is necessary when the permanganate method is employed, as half of the formaldehyde is destroyed by the reaction. For disinfecting 1,000 cubic feet, therefore, use 20 ounces of formalin and 16 2/3 ounces of permanganate. The needle-shaped crystals of potassium permanganate should be employed. Place the required amount of permanganate in a wide-bottomed vessel (an ordinary dishpan is excellent) and pour the formalin on quickly, then close the compartment for from six to twelve hours, depending upon the character of the materials to be disinfected.

Production of the Gas from Paraform and from Wood Alcohol.—(*a*) Heating Paraform.—Lamps provided with a pan for holding the paraform are obtainable on the market. The paraffin is placed in the pan and heat applied by means of an alcohol lamp. The evolution of gas in this manner is slow. Two ounces of paraform is required for the disinfection of 1,000 cubic feet of space, and the compartment should remain closed for at least twelve hours. This method is best suited to the disinfection of small spaces.

(*b*) Generation of Formaldehyde from Wood Alcohol.—Formaldehyde is readily produced by the oxidation of wood alcohol (methyl alcohol). This fact has been taken advantage of for use in practical disinfection. Lamps have been designed by means of which the vapor of wood alcohol is passed over hot, finely divided platinum. This causes the oxidation of the alcohol to formaldehyde, which is given off in the room to be disinfected. There is somewhat more danger from fire when this method is employed than in those previously described. Not less than 25 ounces of wood alcohol should be employed for disinfecting 1,000 cubic feet of space.

Advantages and Disadvantages of Formaldehyde.—The advantages may be summarized as follows:

(1) It is one of the most powerful germicides known.

(2) Its action is not interfered with by albuminous substances.

(3) It is not poisonous and may therefore be used for disinfecting hay and grain without destroying these for food purposes.

(4) It is not injurious to delicate fabrics, paint, or metals. (Formalin solutions will attack iron, but not other metals.)

The disadvantages are, briefly, as below:

(1) The gas has a strong tendency to condense in cold weather and is not reliable as a disinfectant when the air temperature is below 50 deg. F.

(2) It is necessary to seal tightly all compartments which are to be disinfected with the gas in order that penetration may be secured and that the required concentration may be maintained for a sufficient length of time.

CARBOLIC ACID (PHENOL.)

Pure carbolic acid is solid at ordinary temperatures and crystallizes in long white needles. It may be purchased in this form or as liquefied carbolic acid (Phenol liquefactum, U. S. P.). The latter form is prepared by adding 1 part of water to 9 parts of the crystals and is employed by pharmacists on account of convenience in dispensing. Carbolic acid must not be confused with "crude carbolic acid" and "liquid carbolic acid," which are described below.

For disinfecting purposes carbolic acid is generally used in water solution, though powders containing it are sold. A 5 per cent solution of crystallized carbolic acid in water is recommended for general use, for, although weaker solutions have been found efficient for destroying many non-spore-bearing bacteria, the conditions found in practice vary widely and in some cases hinder the action of the disinfectant. As carbolic acid dissolves slowly, the 5 per cent solution should be prepared with warm water, using care to see that all is dissolved before use. For disinfecting large surfaces a spray may be used and the disinfectant should be applied liberally. Garments or implements to be disinfected should remain in the 5 per cent solution for at least one hour.

Advantages and Disadvantages of Carbolic Acid.—The advantages are:

(1) It is reasonably effective for destroying non-spore-bearing bacteria.

(2) Its action is only slightly interfered with by albuminous substances.

(3) It does not destroy metals or fabrics in a 5 per cent solution.

(4) It is readily available at all pharmacies.

The following disadvantages may be mentioned:

(1) It can not be depended upon to destroy the spores of such bacteria as anthrax and malignant edema.

(2) It is expensive (the pure phenol costs approximately 75 cents per pound).

CRUDE CARBOLIC ACID.

Probably no substance is so widely used in this country as a household and farm disinfectant as crude carbolic acid, and at the same time there is probably no disinfectant that is so uncertain in its effect if used without a proper understanding of its nature. The commercial crude carbolic acid is one of the products of coal-tar distillation, and consists essentially of a mixture of coal-tar oils and so-called "cresylic acid" with little or no phenol. The oils are practically inert as disinfectants, but the cresylic acid, which is a mixture of cresols and similar homologues of carbolic acid, has very marked disinfecting power.

As crude carbolic acid depends almost exclusively upon the cresylic acid which it contains for its disinfecting power, it should not be employed unless the cresylic acid content is definitely known. Even then it must be regarded as of doubtful efficiency if the percentage of hydrocarbon oils is relatively very large, for the oil will prevent to a great extent the solution of the cresylic acid in water when this is mixed with the crude carbolic acid for use as a disinfectant. As is stated in the paragraph dealing with cresol, the cresylic acid is used in 2 per cent solution in water as a disinfectant. When crude carbolic acid is employed, the amount of "acid" which it contains should be known and the disinfecting solution should be made of such strength that it will contain 2 per cent of cresylic acid. This disinfecting solution or mixture is best applied by means of a spray pump, and while spraying the mixture should be well agitated in order that the oils containing undissolved cresols may be evenly distributed over the surface to be disinfected.

There are found on the market products which are sold as "liquid carbolic acid," "straw-colored carbolic acid," etc.; these, as a rule, contain from 90 to 98 per cent of cresylic acid and very little coal-tar oil. They are considered in the next section dealing with cresols.

CRESOL.

Cresol (tricresol, straw-colored carbolic acid, liquid carbolic acid) is derived from coal tar and is found in the trade in varying degrees of purity. The cresol of the United States Pharmacopœia is a colorless liquid, having a strong odor resembling that of carbolic acid. It consists of a mixture of three closely related bodies, all of which are superior to carbolic acid as disinfectants. The other grades of cresols usually contain a small percentage of impurities, and are sold as "liquid carbolic acid, 95 per cent," "straw-colored carbolic acid," etc. These usually contain from 90 to 98 per cent of cresol, and may be purchased under a guaranty to contain certain definite amounts of cresylic acid. Grades containing less than 90 per cent of cresylic acid are not so desirable as those of a higher degree of purity, as the coal-tar oils which are usually found in such products interfere with the solution of the cresols in water, as already stated.

The commercial cresols guaranteed to contain more than 90 per cent of cresylic acid are relatively cheap and well suited to the disinfection of cars, barns, and yards. For general disinfection a 1½ to 2 per cent solution of cresol in water should be used, allowance being made for the impurities when the cheaper grades are employed. Cresol is not easily soluble in water; therefore, in preparing solutions warm water should be used and care taken to see that all is dissolved before applying the solution. A 2 per cent solution of cresol is regarded as being a more efficient disinfectant than a 5 per cent solution of carbolic acid and should be applied in the same way.

Advantages and Disadvantages of Cresol.—Briefly, the advantages are:

(1) A 2 per cent solution of cresol is as efficient as a 5 per cent solution of carbolic acid.

(2) It is not interfered with by albuminous substances.

(3) It is cheaper than carbolic acid.

(4) It does not destroy metals or fabrics in a 2 per cent solution.

(5) It is more effective than carbolic acid for destroying spores of bacteria, such as anthrax.

The main drawback to the use of cresol is that it is not readily soluble in water, hence may be used in too weak solution unless great care is taken in the preparation of the solution.

Compound Solution of Cresol.—This preparation, known as liquor cresolis compositus, United States Pharmacopœia, is recognized as official by the last edition of the United States Pharmacopœia, and is a mixture of equal parts of cresol (U. S. P.) with linseed-oil-potash soap. The mixture is a thick, dark, amber-colored fluid which mixes readily with water in all proportions to form a clear soapy solution. A very efficient disinfectant may be made from the commercial cresols or liquid carbolic acids of known strength by mixing these with the soap described in the United States Pharmacopœia under the heading "Liquor Cresolic Compositus." When other than United States Pharmacopœia cresol is used a sufficient excess must be added to insure 50 per cent of actual cresylic acid in the mixture. Compound solution of cresol is recommended for use as a general disinfectant in a 3 to 4 per cent solution in water. In this strength it will accomplish the same results as a 1½ to 2 per cent solution of cresol and may be applied in the same manner as a 5 per cent solution of carbolic acid.

It may be said in favor of the compound solution of cresol that it possesses all the advantages of cresol, and in addition is far more readily soluble. It is, however, somewhat more expensive than cresol, owing to a stronger solution being required; this is in great measure compensated for by its ready solubility.

CHLORINATED LIME (CHLORIDE OF LIME).

This substance is prepared by exposing slaked lime to the action of chlorin gas. It is a white powder which gives off a disagreeable odor of chlorin, and decomposes rapidly upon exposure to air. It can not be depended upon unless kept in hermetically sealed containers. It is prepared for use in the general disinfection of cars, pens, or refuse by mixing 6 ounces with a gallon of water. This is applied liberally, and infectious excreta must be mixed thoroughly with the solution to insure disinfection. Chlorinated lime is a powerful deodorant and is valuable for use in foul-smelling cesspools and similar places.

As a disinfectant, chlorinated lime possesses no advantages over formaldehyde, carbolic acid, cresol, etc. It has, moreover, certain disadvantages, chief among which are uncertainty of strength and destructiveness to metals and fabrics.

BICHLORIDE OF MERCURY.

This is a white crystalline substance which is also known as mercuric chloride and corrosive sublimate. It is usually prepared for use in the form of tablets with ammonium chloride, which facilitates the solution of the bichloride in water. The bichloride is used in solution in water in a strength of 1 to 1,000, though solutions 1 to 500 may be employed with correspondingly quicker action on non-spore-bearing bacteria and much more effective action on the spores of bacteria. Bichloride of mercury is a violent poison, and has the property of combining with albuminoids to form inert compounds. These facts necessarily limit its usefulness as a general disinfectant. It should never be used to disinfect excreta, or substances containing blood or serous fluids. Bichloride solutions should not be kept in lead or tin vessels, or poured through lead pipes, as the mercury combines with these metals and injures them, besides affecting the germicidal efficiency of the solution itself.

The chief advantage in the use of bichloride of mercury lies in its great germicidal power when employed under proper conditions. The disadvantages are its poisonous nature, its tendency to attack certain metals, and the interference by albuminoids and other organic substances.

Various salts added in small quantities to the water used in mixing Portland cement appreciably accelerate or retard the setting of the mixture. The setting is retarded by water containing 4 per cent or more of sodium chloride, and by weak solutions of calcium chloride, but the latter salt in concentration higher than 9 per cent acts as an accelerator. Aluminium chloride accelerates, while iron chloride, most soluble sulphates, and even plaster of Paris retard setting. Aluminium sulphate is an accelerator, and in the compound alums its effect preponderates over that of the retarding alkaline sulphates and produces a slight acceleration. The alkaline carbonates accelerate in weak solutions, but soda acts as a retarder when its concentration exceeds 10 per cent. Borax, boric acid, phosphates, chromates, and chromic acid in any concentration retard the setting.

ENGINEERING NOTES.

Preservative treatment will increase the length of life of a loblolly pine railroad tie from five years to twelve years and will reduce the annual charge from 11.52 cents to 9.48 cents, which amounts to a saving of $58.75 per mile.

Nearly one-half of the New York State Barge Canal is at present under contract. The greater part of the plans for the remainder of the canal are completed, and the others are well under way. During the year 1908 contracts to the amount of $13,421,752 were made; so that there are now in force contracts for building 194 miles of canal, the price of which, including all alterations to date, is $35,739,213. Nearly $5,500,000 worth of construction work was done during the year. This is about two and a half times that done in 1907, and eight times the work done in 1906. Toward the close of the past season, work was progressing at the rate of nearly $1,000,000 worth every month.

The Eastern Railway of France has for several years used concrete-covered girders in the construction of bridges over culverts, roads and small streams, where the span does not exceed 40 or 45 feet. A floor is formed of I beams (or old rails for spans of less than 5 feet) placed very close together and maintained in position by the rods and diagonal braces. The interstices are filled with a mass of concrete, the top of which is leveled and covered with successive layers of asphalt, fine concrete, and ballast. The lower surface of the beams may be left bare, but it is usually protected by a metal grating imbedded in concrete. A considerable economy in metal and expense is realized by this construction.

So serious is becoming the question of supplying sleepers for American railways that the Santa Fé system recently sent its manager of the timber and sleeper department on a tour to the Orient and Europe, to make a study of conditions. It was learned, among other things, that three hundred years ago the Japanese government began to conserve its forests, and that, as a result of its foresight, Japan is now selling sleepers to railways in America and Mexico. There is a duty of 20 per cent on each sleeper imported into the United States. That we should be paying a 20 per cent duty on sleepers, states an American contemporary, is one among many constantly accumulating evidences of the thoughtless extravagance with which our magnificent timber supply has been ruthlessly swept away.

According to a report by the German consul at Baku the total production of petroleum in the first nine months of 1907 amounted to 356,017,073 puds, of which 338,949,048 puds were obtained from wells and 9,363,442 puds from "fountains." The production on the lands leased from the government amounted to 153,400,943 puds as compared with 138,547,190 puds in the corresponding period of 1906. The average monthly yield for the first nine months of 1907 was 39,557,453 puds, the corresponding figures for former years being: 1902, 52,960,738; 1903, 49,717,067; 1904, 51,521,825; 1905 (8 months), 43,707,594; and 1906, 37,364,473 puds. On October 1st, the number of borings amounted to 3,894, viz., 1,210 in Balachany, 1,648 in Sabuntschi, 527 in Ramany, and 507 in Bibi-Eibat. During the nine months the number of productive soundings amounted to 2,094. The average price for crude petroleum was: 1905, 19.3 kopecks; 1906, 25.27; and 1907, 27.66 kopecks per pud. The value of the petroleum produced amounted to: 1905, 81,772,790; 1906, 113,786,500; and 1907, 131,385,000 rubles. Note.—1 pud = 36.112 pounds; 1 ruble = 100 kopecks = 2s. 1 1/3d.

ELECTRICAL NOTES.

According to Electrical Engineering, a German firm has recently put a form of heating apparatus on the market which is particularly designed for immersing in the cases of oil-cooled transformers for the purpose of driving moisture out of the oil. It consists merely of a number of resistance units, mounted on an iron frame, connected to take 42 amperes at 440 volts.

The new electric battery, invented in Australia by Bleeck and Love, has been greatly improved. Through improved combination the current capacity has been increased, and the cost of charging reduced by fully 50 per cent by the solution of a common and cheap chemical in place of the peroxide of hydrogen. At a test held before Prof. Lyle of the Melbourne University, every previous trial was easily beaten. One great advantage is that the chlorine gas, which was given off by the original battery, has been entirely eliminated. Prof. Lyle says that the discovery is now a decidedly more businesslike proposition.

The United States Navy Department is about to have erected a wireless tower in Washington, from which it is to be possible to communicate with ships at sea to the distance of 3,000 miles. The specifications require that the tower or station shall be at all times capable of transmitting messages within a radius of 3,000 miles in any navigable direction from Washington, and the messages are not to be interrupted by atmospheric disturbances or interference by neighboring stations. The department has also asked for tenders for two sets of apparatus to be installed on naval vessels, to be capable of transmitting messages to and from a distance of 1,000 miles, and to receive messages from the Washington station at a distance of 3,000 miles at all times.

The ferry between Godesberg and Niederdollendorf, on the Rhine, is now operated by electricity. The boat, which is large enough to accommodate 645 passengers, in addition to vehicles, is propelled by two screws, each coupled directly with a 30-horse-power, series-wound motor, making 300 revolutions per minute. The current is furnished by a storage battery of 160 cells, with a voltage of about 300 and a capacity of 335 ampere hours. The same battery supplies three auxiliary motors, of which one is employed for pumping and the other two operate the landing bridges, which are carried on the boat. The actual time occupied in crossing the ferry averages 4½ minutes. The battery is recharged at Godesberg, after the boat has made eight trips in each direction, when the density of the battery liquid is found to have fallen from 1.25 to 1.15.

Sediment accumulates rapidly in storage batteries and it must be removed frequently in order to prevent the formation of short circuits, which might produce very serious consequences. The operation of cleaning storage batteries, as it is commonly performed, is both tedious and expensive, as it involves removing, replacing, and resoldering all the plates, often occasions breakage of plates and cells and sometimes diminishes the efficiency of the battery in consequence of the imperfect manner in which the connections are made. All this is entirely avoided by the use of a cleaning device which consists essentially of a small pump, acid-proof and with a glass barrel, which is operated by hand, by means of a crank and flywheel. One man works the pump while another moves the end of the suction pipe among the plates so as to draw off all the sediment.

TRADE NOTES AND FORMULÆ.

Erasing Powder.—By thorough mixture of equal parts of alum, sulphur, amber and saltpeter, a good erasing powder can be produced. When using, shake a little of the powder on a fresh ink spot or fresh writing, and rub it off with a clean cloth. The ink will disappear completely.

Maxim's Explosive.—Saltpeter is mixed with sulphur and then paraffine or some other hydrocarbon added. The mixture proportion is 78 : 18 : 10.4 : 11.42. This composition is used alone, or with three times its volume of ordinary gunpowder; it can also be mixed with guncotton to modify the rapidity of explosion of the latter.

Rommel's Pyro Extinguisher.—According to Zundel, this fire extinguishing preparation consists of a concentrated solution of chloride of calcium. A few years ago, Rommel was granted a Belgian patent on the use of chloride of calcium, ammonia salt (sal ammoniac) and borax, dissolved, and decanted from the precipitate, as a means of extinguishing fire; he now appears to have fallen back on the simpler and cheaper chloride of calcium.

Tailors' Chalk.—Ordinary pipe clay is softened in water, working in ultramarine for blue, finely pulverized ocher for yellow, burnt ocher for red, etc., until the mass is very evenly mixed. From this, slabs of the desired size are formed, which, approximately trimmed, are pressed into the oiled wooden or metal molds. After molding, the pieces can be dried in the air, or in a moderately heated place, after which they are ready for use.

An Excellent Mouse and Rat Poison.—500 parts each of lard and carbonate of barium, 5 parts of salicylic acid, an onion, 50 to 100 parts of beef tallow, 50 parts of 20 per cent ammoniacal solution of verdigris. The onion, cut into small pieces, is roasted in fat, to which, according to the season of the year, beef tallow is added, until it becomes quite brown and the fat has acquired the agreeable onion aroma. Add salicylic acid, strain, and stir until partly cooled fat is opaque. Then add the baryta and finally the verdigris solution.

Imitation Snow.—Make a thin fluid paste of dextrine and stir into this sufficient oxide of zinc to produce a fine white color, and with this the twigs of a Christmas tree or any other object may be simply coated on their upper surface by means of a soft brush. The coating is very durable and, particularly when the tree is illuminated, produces the appearance of fresh snow. If we desire to make the deception more realistic the branches, while still sticky, may be sprinkled with diamantine.

To Prevent Mold in Cellars.—For this purpose the cellar walls should be frequently coated with freshly-made lime-white. The surfaces of the casks may be painted with borax solution; for cask faucets, buckets, and funnels, impregnation outside with hot paraffine and washing inside with formaline solution are useful. The latter may also be used in place of sulphuring. For cask stands, cellar steps, and doors, employ impregnation with green vitriol or sulphate of copper solution (formaldehyde used in the proportion of 1 part of formaldehyde to 40 parts of water is an excellent washing and cleansing medium).

Varnish for Wall Paper.—To prepare paper hangings so that they can be washed off with soap and water, they should be coated with the following varnish: Borax and shellac or stick lac of each 30 parts, to be dissolved in 200 parts of hot water, the solution being strained through a fine sieve. The paper hangings are to be coated with this varnish before or after they have been applied to the walls, and when perfectly dry, brushed with a soft brush, whereby they acquire a fine luster. The coating is done twice, the second coat being applied after the first is dry, with a brush, in the ordinary manner. This varnish is intended for dark paper hangings; for light papers, sandarac should be substituted for the shellac.

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